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How the American despatch rider appears in peace-time maneuvers

THE MOTORCYCLE IN WAR—[See page 342]

# The Organization of Thought—I*

## The Basis of Organized Action

By Prof. A. N. Whitehead, Sc.D., F. R. S.

THE subject of this address is the organization of thought, a topic evidently capable of many diverse modes of treatment. I intend more particularly to give some account of that department of logical science with which some of my own studies have been connected. But I am anxious, if I can succeed in so doing, to handle this account so as to exhibit the relation with certain considerations which underlie general scientific activities.

It is no accident that an age of science has developed into an age of organization. Organized thought is the basis of organized action. Organization is the adjustment of diverse elements so that their mutual relations may exhibit some predetermined quality. An epic poem is a triumph of organization; that is to say, it is a triumph in the unlikely event of it being a good epic poem. It is the successful organization of multitudinous sounds of words, associations of words, pictorial memories of diverse events and feelings ordinarily occurring in life, combined with a special narrative of great events: the whole so disposed as to excite emotions which, as defined by Milton, are simple, sensuous, and passionate. The number of successful epic poems is commensurate, or, rather, is inversely commensurate with the obvious difficulty of the task of organization.

Science is the organization of thought. But the example of the epic poem warns us that science is not any organization of thought. It is an organization of a certain definite type which we will endeavor to determine.

Science is a river with two sources, the practical source and the theoretical source. The practical source is the desire to direct our actions to achieve predetermined ends. For example, the British nation, fighting for justice, turns to science, which teaches it the importance of compounds of nitrogen. The theoretical source is the desire to understand. Now I am going to emphasize the importance of theory in science. But to avoid misconception I most emphatically state that I do not consider one source as in any sense nobler than the other, or intrinsically more interesting. I cannot see why it is nobler to strive to understand than to busy oneself with the right ordering of one's actions. Both have their bad sides; there are evil ends directing actions, and there are ignoble curiosities of the understanding.

The importance, even in practice, of the theoretical side of science arises from the fact that action must be immediate, and takes place under circumstances which are excessively complicated. If we wait for the necessities of action before we commence to arrange our ideas, in peace we shall have lost our trade, and in war we shall have lost the battle.

Success in practice depends on theorists who, led by other motives of exploration, have been there before, and by some good chance have hit upon the relevant ideas. By a theorist I do not mean a man who is up in the clouds but a man whose motive for thought is the desire to formulate correctly the rules according to which events occur. A successful theorist should be excessively interested in immediate events, otherwise he is not at all likely to formulate correctly anything about them. Of course, both sources of science exist in all men.

Now, what is this thought organization which we call science? The first aspect of modern science which struck thoughtful observers was its inductive character. The nature of induction, its importance, and the rules of inductive logic have been considered by a long series of thinkers, especially English thinkers—Bacon, Herschel, J. S. Mill, Venn, Jevons, and others. I am not going to plunge into an analysis of the process of induction. Induction is the machinery and not the product, and it is the product which I want to consider. When we understand the product we shall be in a stronger position to improve the machinery.

First, there is one point which it is necessary to emphasize. There is a tendency in analyzing scientific processes to assume a given assemblage of concepts applying to nature, and to imagine that the discovery of laws of nature consists in selecting by means of inductive logic some one out of a definite set of possible alternative relations which may hold between the things in nature answering to these obvious concepts. In a sense this assumption is fairly correct, especially in regard to the earlier stages of science. Mankind found itself in possession of certain concepts respecting nature—for example, the concept of fairly permanent material bodies—and proceeded to determine laws which related the corresponding percepts in nature. But the formulation of laws changed the concepts, sometimes gently by an added precision, sometimes violently. At first this process was not much noticed, or at least was felt to be a process curbed within narrow bounds, not touching fundamental ideas. At the stage where we now are, the formulation of the concepts can be seen to be as important as the formulation of the empirical laws connecting the events in the universe as thus conceived by us. For example, the concepts of life of heredity, of a material body, of a molecule, of an atom, of an electron, of energy, of space, of time, of quantity, and of number. I am not dogmatizing about the best way of getting such ideas straight. Certainly it will only be done by those who have devoted themselves to a special study of the facts in question. Success is never absolute, and progress in the right direction is the result of a slow, gradual process of continual comparison of ideas with facts. The criterion of success is that we should be able to formulate empirical laws, that is, statements of relations, connecting the various parts of the universe as thus conceived, laws with the property that we can interpret the actual events of our lives as being our fragmentary knowledge of this conceived interrelated whole.

But, for the purposes of science, what is the actual world? Has science to wait for the termination of the metaphysical debate till it can determine it own subject-matter? I suggest that science has a much more homely starting-ground. Its task is the discovery of the relations which exist within that flux of perceptions, sensations, and emotions which forms our experience of life. The panorama yielded by sight, sound, taste, smell, touch, and by more inchoate sensible feelings, is the sole field of its activity. It is in this way that science is the thought organization of experience. The most obvious aspect of this field of actual experience is its disorderly character. It is for each person a *continuum*, fragmentary, and with elements not clearly differentiated. The comparison of the sensible experiences of diverse people brings its own difficulties. I insist on the radically untidy, ill-adjusted character of the fields of actual experience from which science starts. To grasp this fundamental truth is the first step in wisdom when constructing a philosophy of science. This fact is concealed by the influence of language, moulded by science, which foists on us exact concepts as though they represented the immediate deliverances of experience. The result is that we imagine that we have immediate experience of a world of perfectly defined objects implicated in perfectly defined events which, as known to us by the direct deliverance of our senses, happen at exact instants of time, in a space formed by exact points, without parts and without magnitude: the neat, trim, tidy, exact world which is the goal of scientific thought.

My contention is that this world is a world of ideas, and that its internal relations are relations between abstract concepts, and that the elucidation of the precise connection between this world and the feelings of actual experience is the fundamental question of scientific philosophy. The question which I am inviting you to consider is this: How does exact thought apply to the fragmentary, vague *continua* of experience? I am not saying that it does not apply, quite the contrary. But I want to know how it applies. The solution I am asking for is not a phrase however brilliant, but a solid branch of science, constructed with slow patience, showing in detail how the correspondence is effected.

The first great steps in the organization of thought were due exclusively to the practical source of scientific activity, without any admixture of theoretical impulse. Their slow accomplishment was the cause and also the effect of the gradual evolution of moderately rational beings. I mean the formation of the concepts of definite material objects, of the determinate lapse of time, of simultaneity, of recurrence, of definite relative position, and of analogous fundamental ideas, according to which the flux of our experience is mentally arranged for handy reference; in fact, the whole apparatus of common-sense thought. Consider in your mind some definite chair. The concept of that chair is simply the concept of all the interrelated experiences connected with that chair—namely, of the experiences of the folk who made it, of the folk who sold it, of the folk who have seen it or used it, of the man who is now experiencing a comfortable sense of support, combined with our expectations of an analogous future, terminated finally by a different set of experiences when the chair collapses and becomes firewood. The formation of that type of concept was a tremendous job, and zoologists and geologists tell us that it took many tens of millions of years. I can well believe it.

I now emphasize two points. In the first place, science is rooted in what I have just called the whole apparatus of common-sense thought. That is the *datum* from which it starts, and to which it must recur. We may speculate, if it amuses us, of other beings in other planets who have arranged analogous experiences according to an entirely different conceptual code—namely, who have directed their chief attention to different relations between their various experiences. But the task is too complex, too gigantic, to be revised in its main outlines. You may polish up common sense, you may contradict it in detail, you may surprise it. But ultimately your whole task is to satisfy it.

In the second place, neither common sense nor science can proceed with their task of thought organization without departing in some respect from the strict consideration of what is actual in experience. Think again of the chair. Among the experiences upon which its concept is based I included our expectations of its future history. I should have gone further and included our imagination of all the possible experiences which in ordinary language we should call perceptions of the chair which might have occurred. This is a difficult question, and I do not see my way through it. But at present in the construction of a theory of space and of time there seem insuperable difficulties if we refuse to admit ideal experiences.

This imaginative perception of experiences, which, if they occurred, would be coherent with our actual experiences, seems fundamental in our lives. It is neither wholly arbitrary nor yet fully determined. It is a vague background which is only made in part definite by isolated activities of thought. Consider, for example, our thoughts of the unseen flora of Brazil.

Ideal experiences are closely connected with our imaginative reproduction of the actual experiences of other people, and also with our almost inevitable conception of ourselves as receiving our impressions from an external complex reality beyond ourselves. It may be that an adequate analysis of every source and every type of experience yields demonstrative proof of such a reality and of its nature. Indeed, it is hardly to be doubted that this is the case. The precise elucidation of this question is the problem of metaphysics. One of the points which I am urging in this address is that the basis of science does not depend on the assumption of any of the conclusions of metaphysics; but that both science and metaphysics start from the same given groundwork of immediate experience, and in the main proceed in opposite directions on their diverse tasks.

For example, metaphysics inquires how our perceptions of the chair relate us to some true reality. Science gathers up these perceptions into a determinate class, adds to them ideal perceptions of analogous sort, which under assignable circumstances would be obtained, and this single concept of that set of perceptions is all that science needs; unless indeed you prefer that thought find its origin in some legend of those great twin brethren, the Cock and Bull.

My immediate problem is to inquire into the nature of the texture of science. Science is essentially logical. The nexus between its concepts is a logical nexus, and the grounds for its detailed assertions are logical grounds. King James said, "No bishops, no King." With greater confidence we can say, "No logic, no science." The reason for the instinctive dislike which most men of science feel towards the recognition of this truth is, I think, the barren failure of logical theory during the past three or four centuries. We may trace this failure back to the worship of authority which in some respects increased in the learned world at the time of the Renaissance. Mankind then changed its authority, and this fact temporarily acted as an emancipation. But the main fact, and we can find complaints (*e. g.*, in 1551 by Italian schoolmen) of it at the very commencement of the modern movement, was the establishment of a reverential attitude towards any statement made by a classical author. Scholars became commentators on truths too fragile to bear translation. A science which hesitates to forget its founders is lost. To this hesitation I ascribe the barrenness of logic. Another reason for distrust of logical theory and of mathematics is the belief that deductive reasoning can give you nothing new. Your conclusions are contained in your premises, which by hypothesis are known to you.

*An address to the Mathematical and Physical Science Section of the British Association, at Newcastle. Reported in *The Chemical News*.

In the first place this last condemnation of logic neglects the fragmentary, disconnected character of human knowledge. To know one premise on Monday, and another premise on Tuesday, is useless to you on Wednesday. Science is a permanent record of premises, deductions, and conclusions, verified all along the line by its correspondence with facts. Secondly, it is untrue that when we know the premises we also know the conclusions. In arithmetic, for example, mankind are not calculating boys. Any theory which proves that they are conversant with the consequences of their assumptions must be wrong. We can imagine beings who possess such insight. But we are not such creatures. Both these answers are, I think, true and relevant. But they are not satisfactory. They are too much in the nature of bludgeons, too external. We want something more explanatory of the very real difficulty which the question suggests. In fact, the true answer is embedded in the discussion of our main problem of the relation of logic to natural science.

It will be necessary to sketch in broad outline some relevant features of modern logic. In doing so I shall try to avoid the profound general discussions and the minute technical classifications which occupy the main part of traditional logic. It is characteristic of a science in its earlier stages—and logic has become fossilized in such a stage—to be both ambitiously profound in its aims and trivial in its handling of details. We can discern four departments of logical theory. By an analogy which is not so very remote I will call these departments or sections the arithmetic section, the algebraic section, the section of general-function theory, the analytic section. I do not mean that arithmetic arises in the first section, algebra in the second section, and so on; but the names are suggestive of certain qualities of thought in each section which are reminiscent of analogous qualities in arithmetic, in algebra, in the general theory of a mathematical function, and in the analysis of the properties of particular functions.

The first section—namely, the arithmetic stage—deals with the relations of definite propositions to each other, just as arithmetic deals with definite numbers. Consider any definite proposition; call it "$p$." We conceive that there is always another proposition which is the direct contradictory to "$p$"; call it "not-$p$." When we have got two propositions, $p$ and $q$, we can form derivative propositions from them and from their contradictories. We can say, "At least one of $p$ or $q$ is true, and perhaps both." Let us call this proposition "$p$ or $q$." I may mention as an aside that one of the greatest living philosophers has stated that this use of the word "or—namely, "$p$ or $q$" in the sense that either or both may be true—makes him despair of exact expression. We must brave his wrath, which is unintelligible to me.

We have thus got hold of four new propositions, namely, "$p$ or $q$," and "not-$p$ or $q$," and "$p$ or not-$q$," and "not-$p$ or not-$q$." Call these the set of disjunctive derivatives. There are, so far, in all eight propositions, $p$, not-$p$, $q$, not-q, and the four disjunctive derivatives. Any pair of these eight propositions can be taken and substituted for $p$ and $q$ in the foregoing treatment. Thus each pair yields eight propositions, some of which may have been obtained before. By proceeding in this way we arrive at an unending set of propositions of growing complexity, ultimately derived from the two original propositions $p$ or $q$. Of course only a few are important. Similarly we can start from three propositions, $p$, $q$, $r$, or from four propositions, $p$, $q$, $r$, $s$, and so on. Any one of the propositions of these aggregates may be true or false. It has no other alternative. Whichever it is, true or false, call it the "truth-value" of the proposition.

The first section of logical inquiry is to settle what we know of the truth values of these propositions, when we know the truth-values of some of them. The inquiry, so far as it is worth while carrying it, is not very abstruse, and the best way of expressing its results is a detail which I will not now consider. This inquiry forms the arithmetic stage.

The next section of logic is the algebraic stage. Now, the difference between arithmetic and algebra is that in arithmetic definite numbers are considered, and in algebra symbols—namely, letters—are introduced which stand for any numbers. The idea of a number is also enlarged. These letters, standing for any numbers, are called sometimes variables and sometimes parameters. Their essential characteristic is that they are undetermined, unless, indeed, the algebraic conditions which they satisfy implicitly determine them. Then they are sometimes called unknowns. An algebraic formula with letters is a blank form. It becomes a determinate arithmetic statement when definite numbers are substituted for the letters. The importance of algebra is a tribute to the study of form. Consider now the following proposition,

The specific heat of mercury is 0.033

This is a definite proposition which, with certain limitations, is true. But the truth-value of the proposition does not immediately concern us. Instead of mercury put a mere letter which is the name of some undetermined thing; we get,

The specific heat of $x$ is 0.033

This is not a proposition; it has been called by Russell a propositional function. It is the logical analogy of an algebraic expression. Let us write $f(x)$ for any propositional function.

We could also generalize still further, and say,

The specific heat of $x$ is $y$.

We thus get another propositional function, $F(x, y)$ of two arguments $x$ and $y$, and so on for any number of arguments.

Now, consider $f(x)$. There is the range of values of $x$, for which $f(x)$ is a proposition, ture or false. For values of $x$ outside this range, $f(x)$ is not a proposition at all, and is neither true nor false. It may have vague suggestions for us, but it has no unit meaning of definite assertion. For example,

The specific heat of water is 0.033

is a proposition which is false; and

The specific heat of virtue is 0.033

is, I should imagine, not a proposition at all; so that it is neither true nor false, though its component parts raise various associations in our minds. This range of values, for which $f(x)$ has sense, is called the "type" of the argument $x$.

But there is also a range of values of $x$ for which $f(x)$ is a true proposition. This is the class of those values of the argument which *satisfy* $f(x)$. This class may have no members, or, in the other extreme, the class may be the whole type of the arguments.

We thus conceive two general propositions respecting the indefinite number of propositions which share in the same logical form, that is, which are values of the same propositional function. One of these propositions is,

$f(x)$ yields a true proposition for each value of $x$ of the proper type;

the other proposition is,

There is a value of $x$ for which $f(x)$ is true

Given two, or more, propositional functions $f(x)$ and $\phi(x)$ with the same argument $x$, we form derivative propositional functions, namely,

$f(x)$ or $\phi(x)$, $f(x)$ or not $\phi(x)$,

and so on with the contradictories, obtaining, as in the arithmetical stage, an unending aggregate of propositional functions. Also each propositional function yields two general propositions. The theory of the interconnection between the truth-values of the general propositions arising from any such aggregate of propositional functions forms a simple and elegant chapter of mathematical logic.

In this algebraic section of logic the theory of types crops up, as we have already noted. It cannot be neglected without the introduction of error. Its theory has to be settled at least by some safe hypothesis, even if it does not go to the philosophic basis of the question. This part of the subject is obscure and difficult, and has not been finally elucidated, though Russell's brilliant work has opened out the subject.

The final impulse to modern logic comes from the independent discovery of the importance of the logical variable by Frege and Peano. Frege went further than Peano, but by an unfortunate symbolism rendered his work so obscure that no one fully recognized his meaning who had not found it out for himself. But the movement has a large history reaching back to Liebniz and even to Aristotle. Among English contributors are De Morgan, Boole, and Sir Alfred Kempe; their work is of the first rank.

The third logical section is the stage of general-function theory. In logical language, we perform in this stage the transition from intension to extension, and investigate the theory of denotation. Take the propositional function $f(x)$. There is the class, or range of values for $x$, whose members satisfy $f(x)$. But the same range may be the class whose members satisfy another propositional function $\phi(x)$. It is necessary to investigate how to indicate the class by a way which is indifferent as between the various propositional functions which are satisfied by any member of it, and of it only. What has to be done is to analyze the nature of propositions about a class—namely, those propositions whose truth-values depend on the class itself and not on the particular meaning by which the class is indicated.

Furthermore, there are propositions about alleged individuals indicated by descriptive phrases: for example, propositions about "the present King of England," who does exist, and "the present Emperor of Brazil," who does not exist. More complicated, but analogous, questions involving propositional functions of two variables involve the notion of "correlation," just as functions of one argument involve classes. Similarly functions of three arguments yield three-cornered correlations, and so on. This logical section is one which Russell has made peculiarly his own by work which must always remain fundamental. I have called this the section of functional theory, because its ideas are essential to the construction of logical denoting functions which include as a special case ordinary mathematical functions such as sine, logarithm, etc. In each of these three stages it will be necessary gradually to introduce an appropriate symbolism, if we are to pass on to the fourth stage.

[TO BE CONTINUED]

## The Composition of Power Gases

THE author called attention to the fact that the development of the gas engine since its early days has been entirely independent of the varying composition of power gases, while the proper method of using them has been mainly the result of experiments in the testing shops at manufacturers' works. He referred to the scientific research work that had been carried out in connection with the working fluid of internal combustion engines, but stated his opinion that this work was somewhat of a negative character as far as the gas engine maker was concerned, and the progress in gas engine work had not been greatly assisted by science.

Reference was made to an extended series of tests which the author had carried out for the two chief London gas companies since 1911, and to the necessity that arose in connection with those tests of instituting a basis of comparison other than the usual statements with regard to consumption of gas per cubic foot to indicated horsepower developed. In this way it had been found far preferable to compare the outputs of widely varying engines in respect of mean pressure developed behind the piston per unit of mixture strength, and it was shown that upon this basis the performance of internal combustion engines, whether working with liquid or gaseous fuels of all the various kinds in use, were wonderfully similar, and, indeed, practically identical when account was taken of the clearance volume ratios of the engines concerned.

A chart was exhibited showing output consumption curves of eight very dissimilar engines in support of this fact, and from this the author deduced that as far as the composition of gas was concerned, it mattered little to the internal combustion engineer. What was of more concern to him was the calorific value of the strength of mixture; that is to say, of the gas, air, and residuals which took part in the combustion at each impulse.

The author proceeded to point out that having regard to mixture strength basis in proportion to mean pressure developed on the system he enunciated, it was clear that the progress of the last 30 years could be explained, namely, that in general terms the reduction in the rate of gas consumption has been coincident with the decrease of clearance volume in relation to total cylinder volume which mechancial improvements have permitted and as time brought about new methods of ignition.

The author stated that in his practice he endeavored, first of all, to obtain such mixture strength as his experience had found to be practically universal for full load outputs whatever the size or type of engine. By properly correlating the ignition-point and noting the shape of the indicator diagram then secured, one could almost tell what the consumption of gas was without the use of any gas measuring device, so uniform seemed to be the operation of the engines in respect of gas consumption.

The author then proceeded to discuss the effect upon variations in calorific value, pressure, etc., upon the engine, keeping the supply of air constant. He gave charts showing the recorded variations in composition and calorific value of suction gas at full load and no load, and also exhibited a chart showing that however wide the variation calorific value in various power gases ranging from natural gas to blast-furnace gas, yet when these had been mixed with the theoretically correct proportion of air to provide complete combustion, there was very little difference between them, or rather that the range of variation in quality was greatly limited, more so than would at first sight appear to be possible.

The author then dealt with the next question of pre-ignition, and discussed whether the hydrogen percentage in gas composition was actually so troublesome as it was commonly supposed to be. He gave practical examples of pre-ignition troubles which rather tended to show that the proportion of hydrogen content has very little to do with it, and that it was more likely that pre-ignition troubles of the nature alluded to was consequent upon a change from a slow burning mixture to one which was fierce to burn.

In conclusion, the author stated that as far as his experience went he thought that, speaking generally, the actual composition of power gases was not of great importance, and certainly of much less importance than the cleanliness, uniformity of pressure, and invariable composition.—An abstract from the *Chemical News* of a paper read before the London Section of the Society of Chemical Industry, by W. A. TOOKEY, M.I., Mech. Eng.

# The Beginning of War-Machines*

## Former Day Types of Explosive Missile

Among the numerous types of weapon used in the present war the hand-grenade holds a special position as being one of the old devices reintroduced after a period of disuse. Its name "grenade" is said to have been derived from its resemblance to the "Punic apple," or pomegranate, which is, as everybody knows, a spherical fruit containing within its rind a vast number of seeds. Baked earthenware vessels containing quicklime (Fig. 1), poisonous juices, putrefying animal matter, and similar noxious substances, were apparently the earliest sort of hand-grenades as employed in war among the ancients. We hear of explosive hand-grenades for the first time at the siege of St. Bonifacio in 1421, and afterwards again at the siege of Arles in 1536.

Fire-balls (Fig. 6) and a "fiery wheel" (Fig. 7) designed to adhere to the clothing on contact were made in the sixteenth century. An interesting description of these "fiery wheels" by Nathaniel Nye, the "Master Gunner of the City of Worcester," ends with this expression of opinion as to their efficacy: "Their falling upon any man he cannot choose but be much astonished with such a fearful element and put his company in great disorder." It would appear that these pyrotechnic wheels and garlands were devised at this period to take the place of the bomb on occasion: "because every soldier would not meddle with hand grenades, the use of them being somewhat dangerous." Vessels of glass or earthenware (Fig. 8) containing 3½ to 7½ oz. of powder are of sixteenth-century design. Several sixteenth-century hand-grenades of a coarse glass, almost slag, from Rhodes, may be seen in the Rotunda Museum at Woolwich. They hold from 3.4 oz. to 7.4 oz. of powder, and are about 3.6 inch in diameter. Six are of a red glass, two of light-green, four a dark-green. Figs. 2, 3, and 4 show various incendiary devices intended to be thrown by means of cord slings after being ignited. Hand-grenades are still thrown by means of the sling (see *Illustrated War News*, Dec. 9, 1914). The earliest historical notice of the sling dates about B. C. 1406 (see Judges, xx., 16). Fig. 5 illustrates a staff sling for propelling a similar grenade missile.

In Fig. 12 we see a part section of a "percussion" or "blind" grenade, as it was then called. The device was provided with a friction firing tube holding a leaden ball attached to the firing plug. Sprigs of box-leaves formed a tail, designed so as to cause the grenade to travel and fall in such a position that, on its motion being arrested suddenly, the momentum of the leaden ball carried the ball along the tube. That caused it to explode the bomb by pulling the firing plug to which it was attached.

**Forerunners of the "Great War" Hand-Grenade**

Another "blind" bomb (Fig. 10) was provided with a firing device consisting of a perforated metal tube (Fig. 10—*a*), rough on its inner surface, which passed through the center of the sphere and was attached to it. A sliding rod (Fig. 10—*b*), the upper end of which was situated within the tube, carried a pair of flint igniters (Fig. 10—*c c*) having their lower ends secured to a circular foot (as in Fig. 10). Sling loops opposite the foot acted as a tail, and the weapon was exploded by sparks struck between the flints and the tube when the foot came into contact with the ground or target. A "stationary" bomb, or portable mine, is seen at Fig. 11. It consisted of a hollow metal sphere containing a bursting charge fired by a slow match. The match passed through a perforated tube provided for the purpose.

The forerunner of the rifle-grenade of today was, in the seventeenth century, fired by means of a grenade cup (Figs. 16 and 17). In that manner spherical grenades were propelled from muskets. Louis XIV, of France was the first European sovereign to enroll grenade-throwers, or grenadiers, as a distinct unit in his army. A number of picked men of tall stature and stalwart physique were specially trained in the service and attached by companies to infantry regiments in 1667. The British army adopted the same course eleven years later. It was not until 1815 that the Grenadier Guards were so styled, and that for an exceptional reason. At one time, also, a troop of Horse Grenadiers was attached to each of the original troops of the Life Guards. Hand-grenades (Figs. 18 and 19) were used by both sides in Paris in the insurrection of the Commune. It may be added in conclusion, that grenades and bombs were thrown in various ways: the smaller types by hand, sling, or musket; the larger by means of trench-mortars, such as the Cohorn of 1690. These methods are used to some extent today. The Orsini grenade (Fig. 19) was an assassination bomb of the pattern employed by Orsini, the would-be assasin of Napoleon III, in Paris in 1858.

**Fig. 18.—"Ring Bomb" or Grenade—Nineteenth Century (After "La Nature")**

The diameter was five inches. Inside was a circular glass tube surrounded by an explosive substance. The glass, when broken by the shock of impact, freed a liquid which ignited the explosive.

### Plants and Asphyxiating Gases

The deleterious gases used in the war not only have the bad effect upon human beings with which we are familiar, but they have such a corrosive nature as to even attack plants, as is now attested by several observers. Different plants are variously affected by the gases, as might be expected. The following are some of the first observations which we have to record: In the Champange region, certain varieties of pine trees were burned or reddened, but not the epicea or the juniper. At Bailleul, situated some five miles from the fighting line, the hothouses belonging to M. Cordonnier suffered not a little from the effects of such gases during the month of April, and this was specially noticed in the case of grape vines, which were already in a fair stage of growth. Here the leaves were not reddened but were covered with white or discolored spots, and afterwards they turned brown and fell off. According the experiments made by M. Viala, chlorine water gives the same results. In hothouses of the closed type the bad effects were very slight on account of the dryness of the air, but in growing houses of the cold air type they were much more noticeable. Other observers noticed a more or less marked effect of the gases upon growing grain, and especially rye. It is considered that the stage of growth as well as the moisture of the air have a certain influence upon the character of these phenomena.

**Fig. 19.—The Orsini Grenade—Nineteenth Century (After "La Nature").**

The sphere of brittle iron was two inches in diameter, and filled with explosive. The hollow nipples studding the missile bore percussion-caps.

*The Illustrated War News (London.)

# Aviation and Aerography

## Something Needed for Constructing Aerographic Charts

By Alexander McAdie, A. Lawrence Rotch Professor of Meteorology, Harvard University

It is nearly fifty years since Lowell wrote, "New occasions teach new duties. Time makes ancient good uncouth." And certainly the truth of the poet's reasoning comes home to us with great force in connection with aviation, the new occasion, and aerography, the new duty. It is apparent that what the hydrographer has done for navigation, and the geographer for exploration, the aerographer must do for the domain of the air.

It will be well to define in a general way, subject of course to later modification, what we mean by the terms used. We would define an aviator as the master of an aeroplane or heavier-than-air machine, one that makes use of the inertia of the air, skimming the air rather than rising by buoyancy.

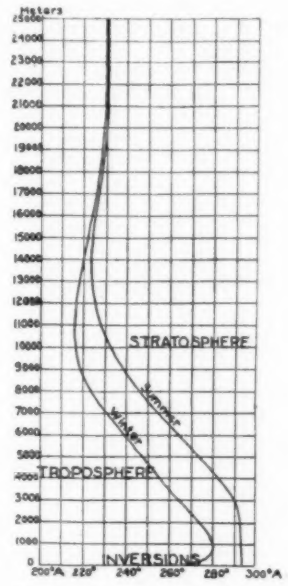



FIG. 1. TEMPERATURE-ALTITUDE GRADIENTS*

By aeronaut, we mean the master or pilot of a balloon or combination of balloon and plane, in which hydrogen is used for flotation. These are essentially lighter-than-air machines, even when provided with high-powered propelling engines.

The aerographer may be defined as a student of the structure of the atmosphere, one who charts the physical conditions at all levels. Aerographic charts would then correspond to the well-known pilot charts, the latter for the surface of the water oceans, while the former would deal not alone with the bottom layer, but with all layers up to 15 or 20 kilometers, in the vastly greater ocean of air. Not only tides and eddies, winds and whirls, currents up and down, must be given, but also all port facilities, remembering that in the air any place and every place may be a port of entry.

The American navigator, though but one vessel now flies his flag, where there should be twenty, still takes pride in recalling that the first great study of winds and oceans currents was the work of an American naval officer. Very appropriately the pilot charts bear the words "Founded upon the researches made and the data collected by Lieut. M. F. Maury, U. S. Navy." Perhaps, then, it need not be wondered at that in the land of Maury, which is also the land of Langley, the Wrights, Chanute and Maxim, there should be published the first volume specifically designed for the use of aviators and aeronauts. I refer to "Charts of the Atmosphere," by Rotch and Palmer, issued in 1911 by John Wiley and Sons.

This volume contains twenty-four charts, which are essentially a summing up of the work done in exploring the air at Blue Hill Observatory for a period of twenty-five years. Kite work began there in this country as early as 1884 and balloon work in 1904. The cloud work, which interlinks the others, began practically with the establishment of the observatory. The volume gives in some detail values of density, pressure, temperature and air motion from sea-level up to 10 or more kilometers.

The aerography of the future, however, must be not limited to one place or country. When the unhappy European conflict shall be ended, perhaps it may be possible by international coöperation to secure and publish a daily map, not like the weather map, showing ground conditions only, and these in some places of doubtful worth, but one giving information at various levels, so that the aviator may prepare his flight accordingly.

Twenty years ago the International Commission for Scientific Aerostation was organized; and but for the war such a digest of data would by this time have been available.

The results of scientific exploration with kites, manned balloons, sounding balloons and pilot balloons are now so extensive that the time is fully ripe for generalization and deduction. Perhaps, however, we shall gain by waiting for the more elaborate data to be obtained from the aeroplane and the aerodrome, to use a word of Langley's, for surely the time is rapidly approaching when fast air route passenger and mail service will be inaugurated.

The logs of aerial flyers will serve just as the logs of the liners have done or the still earlier logs of the sailing vessels of Maury's day, to give a connected story of air disturbance. At present we have only the kite and sounding balloon records, and these, notwithstanding their excellence and the accumulation of data so obtained, are essentially isolated, and if one may use the word, momentary. We need continuous records.

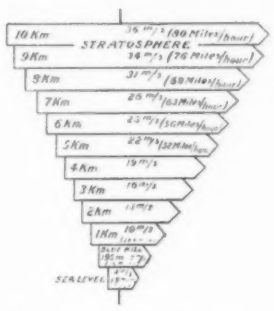



FIG. 2. INCREASE OF VELOCITY WITH ELEVATION

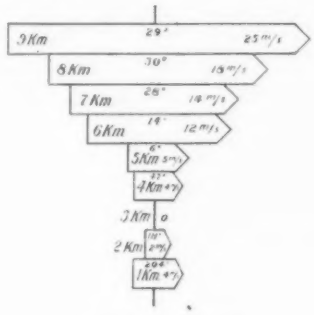



FIG. 3. SEA-BREEZE STRUCTURE

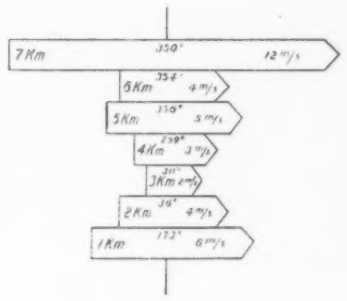



FIG. 4. SEA-TURN STRUCTURE

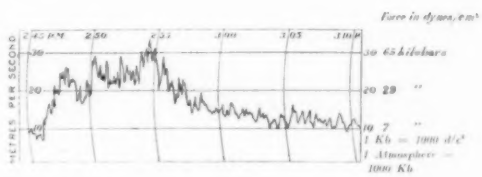



FIG. 5. GUSTINESS (MODIFIED FROM "CHARTS OF THE WIND")

It is true that under the auspices of the International Committee for Scientific Aerostation, soundings have been made at many places, but in nearly all instances the observations are made at times of fair weather and near sunset. The last report makes a remarkable showing of the following coöperating observatories: Trappes, Uccle, Soesterberg, Prinsenberg, Pyrton Hill, Limerick, Manchester, Bergen, Christiania, Copenhagen, Pavia, Monticalieri, Milan, Verona, Ferrara, Modena, Florence, Livorno, Vigna di Valle, Monte Cassino, Mileto, Zürich, Friedrichshafen, Stuttgart, Strassburg, Aachen, Cologne, Hamburg, Lindenburg, Munich, Vienna, Pola, Trieste,

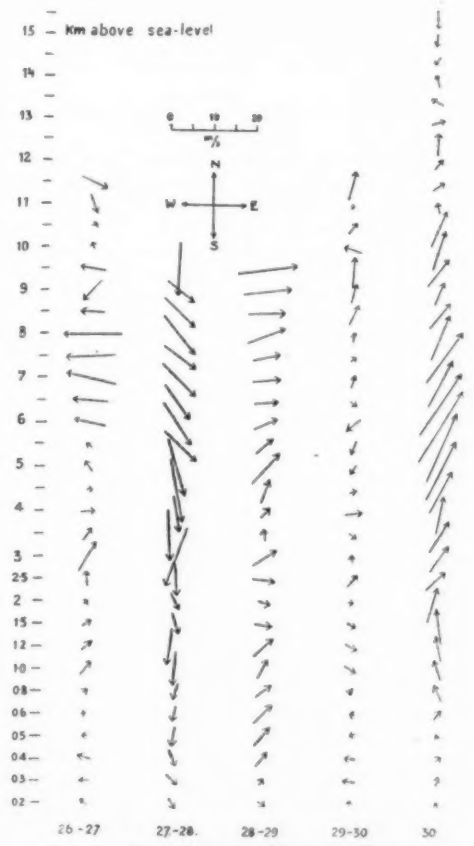



FIG. 7. WIND CHANGES WITHIN A PERIOD OF 24 HOURS

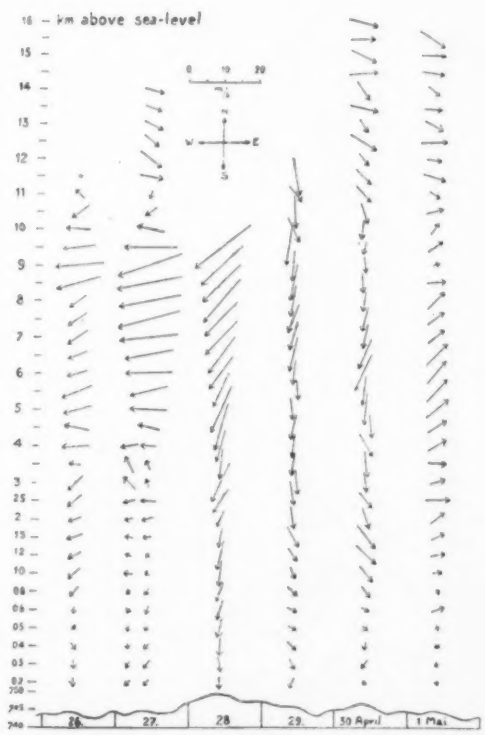



FIG. 6. THE WINDS OVER VIENNA FROM APRIL 26 TO MAY 1, 1915. THE LOWER DIAGRAM SHOWS THE PRESSURE ON THE GROUND

*From *Aviation and Aeronautical Engineering*.

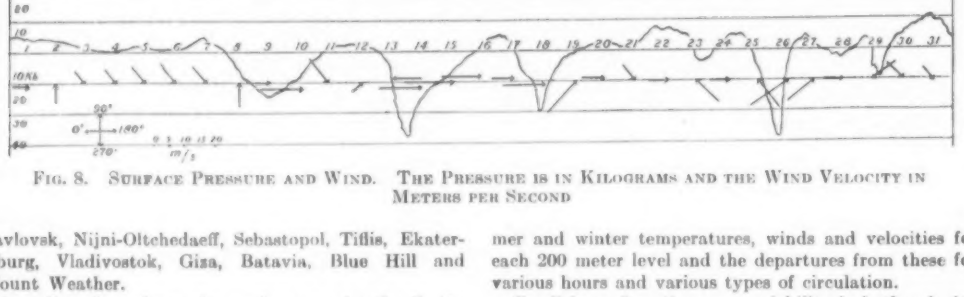



FIG. 8. SURFACE PRESSURE AND WIND. THE PRESSURE IS IN KILOGRAMS AND THE WIND VELOCITY IN METERS PER SECOND

Pavlovsk, Nijni-Oltchedaeff, Sebastopol, Tiflis, Ekaterinburg, Vladivostok, Giza, Batavia, Blue Hill and Mount Weather.

Soundings have been also made at sea by the *Scotia*, sent out by the British Board of Trade as an ice patrol and by our own Coast Guard cutters, *Seneca* and *Tampa*.

One might say what more is needed? The answer is as somewhat foreshadowed above. We need exactly what Maury obtained from his great collection of logs of merchantmen, data that taken individually are fragmentary, but considered together piece out the whole story and enable one without great effort to chart the winds and pressure gradients over wide areas. Thus the logs of aeroplanes in service, carrying, as they undoubtedly will, recording instruments for temperature pressure, wind velocity and direction, will soon furnish information, probably of more direct value than the fragmentary results of observatory soundings by balloons.

There is, of course, no reason why the regular records should not be supplemented from time to time by additional observations of an experimental nature, perhaps with pilot balloons and other devices, although the rapid movement of an aeroplane must invalidate most observational values.

Air explorers have given us much in the long period of their work, 132 years, for we may in all justice say that air exploration began with the ascent of Dr. John Jeffries in 1783, and his successful crossing of the English Channel in January, 1784. In the earlier ascent he obtained good readings of pressure, temperature and humidity, and brought down samples of the air for chemical analysis from various levels up to and exceeding 2 kilometers. So far as I can ascertain, this is the first log to which the aerographer can refer. The instruments then used are in good condition in Boston today.

Two other remarkable men, personal friends and colaborers, may be referred to here as pioneer aerographers, Leon Teisserenc de Bort of Paris and A. Lawrence Rotch of Boston. Their joint work contributed to the discovery of the existence of the stratosphere, or region above which the temperature no longer falls, but may even rise. Some meteorologists refer to this as the isothermal column, but the name suggested by de Bort, stratosphere, is far more appropriate, and is now in widespread use.

In a general way, the stratosphere begins in these latitudes near the 10 kilometer level. Referring to Fig. 1, a temperature-altitude gradient chart, an aviator gets a good idea of temperatures to be expected at different elevations. The higher regions are, of course, beyond consideration for practical purposes. It may not be without interest to give a short table of the extreme elevations reached by various means:

By kite, 7,044 meters at Mount Weather, Va.
By aeroplane, 7,404 meters, Hawker in April, 1916.
By manned balloon, 10,500 meters, Berson, July, 1901.
By sounding balloon, 37,000 meters, at Pavia, Italy.
By pilot balloon, height determined by theodolites, 39,000 meters, at Godhaven.

Most aeroplane work will be done below the 4,000 meter level, and in the winter months below the 2,000 meter level. While temperature is perhaps the most important factor in aviation, the extreme and average wind velocities and durations and directions will need consideration. By reference to Fig. 2, a wind-altitude gradient chart, one gets the average increase of velocity in meters per second per thousand meters rise. The average velocity at a height of 4,000 meters is 19m/s.

In general, the winds are from the west, and there is a steady increase with elevation. The velocity falls off decidedly in the stratosphere. While the general conditions are given in Fig. 2, there are certain well-known and recognizable conditions, such as the sea-breeze and the sea-turn, which are of interest to aviators.

In Fig. 3, showing the structure during sea-breeze, the directions are given in degrees in the center of the arrow and the velocities near the arrow-head. It is thus plain that the sea-breeze is a shallow draft, and in fact is not appreciable above 2,000 meters. For more detailed information the reader is referred to "The Winds of Boston."

Fig 4 illustrated the structure during sea-turn, showing what conditions may normally be expected in advance of a storm from the southwest.

Of course, in such an aerographic chart as has been outlined on this paper, there would be given mean summer and winter temperatures, winds and velocities for each 200 meter level and the departures from these for various hours and various types of circulation.

Conditions of gustiness or variability in both velocity and direction will need the fullest exposition, for this does affect stability. Fig. 5 illustrates the type of wind structure which might well cause pitching and yawing, and it is problematical whether the character of the flight would be at all similar to one in a steady or uniformly varying structure.

Flight at low altitudes is probably more dangerous than at high levels, and it would be of the utmost value in an aerographic chart to locate zones of maximum gustiness. Incidentally, we may remark that the ordinary form of cup anemometer is poorly adapted to give records of the rotary motions of air in all planes. What is wanted is a dynamometer rather than a speedometer.

The writer has elsewhere (*The Geographical Review*, April, 1916[1]) given certain photographs of models showing the structure of the atmosphere on certain dates, based largely upon the models used by Cave in his well-known "Structure of the Atmosphere in Clear Weather." It is not necessary to refer further to them here or to the recent work of Sir Napier Shaw and certain recent views of Dines and others pointing out inconsistencies in the older meteorology, especially in connection with the origin of cyclones and anticyclones, and the role played by convection in their formation.

French, American, British, Italian, German, Austrian and Dutch meteorologists alike contribute their portion to the solution of the great problem of air flow at all reachable levels. An interesting example of such work is a description of the pilot balloon ascents made in Vienna, April 26 to May 1, 1915, given by Dietzius in the *Meteorologische Zeitschrift*, December, 1915, from which Figs. 6 and 7 are taken. The diagrams are self-explanatory.

The aerographic chart would not be complete without full discussion of the distribution of the water vapor at all levels and the various amounts and frequencies of precipitation in all forms, rain, snow, hail and frost and cloudiness. There is always some danger from thunderstorms, and any marked rotary storm from the desert sand-storm to the tornado of the great waterways.

Fig. 8 illustrates the surface pressure and wind direction and velocity during a winter month—to illustrate number of marked storms and duration.

## High Resistance Telephones for Railroad Train Despatching

AT a meeting of the Western Division of the Association of Railway Telegraph Superintendents, Mr. E. C. Keenan, of the New York Central lines, in speaking on the use of telephone developments in railway service, as reported in the *Railway Age-Gazette*, referred particularly to the recent trial on the Cleveland, Cincinnati, Chicago & St. Louis of high resistance receivers on telephone despatching circuits to improve the transmission. This development grew out of the unusual conditions existing during recent months under the very heavy movement of traffic. On one 100-mile division on one day there was a freight train on every siding at the same time and every operator was naturally listening in on the despatcher's line in an attempt to keep the trains moving. This, of course, resulted in weakening the transmission so that the despatcher was very much hindered, and complaint was made. Tests showed that with the way stations cut out, the transmission was normal, and the idea was therefore conceived of using a high voltage receiver at these stations to minimize the effect of leaving the receiver off the hook. Standard receivers used in wireless telephony were secured, these being of the double type, with 1,500 ohms in each receiver, making 3,000 ohms across the line. The installation of these receivers in the 30 stations on this 100-mile circuit improved the transmission so much that it could be classed as good from end to end. Some laboratory tests were then undertaken with these receivers, and it was found that one 1,500-ohm receiver, with a choke coil in series, gave equally good results, and the remaining receivers were, therefore, taken off and used on other circuits.

[1] SCIENTIFIC AMERICAN SUPPLEMENT, No. 2114, July 8, 1916, p. 20.

## The Motorcyle in War

THE fact that our Government has called for bids for supplying 10,000 motorcycles indicates that the value of these machines, as demonstrated in the operations in Europe, is appreciated; but as half the number are to be supplied with sidecars it is uncertain how it is expected to use them. Moreover, the number called for is decidedly small when we consider that the British have over 75,000 such machines in their army alone, without counting the swarms employed by the other allies.

The suggestion that motorcycles with sidecars are valuable for quickly bringing up bodies of armed men to critical points appears plausible at first, but there are no records in European experience that such procedure is practical. These vehicles must use the same roads as the motor transports, and it is obvious that when the fate of thousands of men is depending of the prompt arrival of ammunition the supply train cannot be delayed by a small detachment of motorcycles. The ammunition train must have the absolute right of way, and on narrow roads it is impossible to keep the sidecar combination out of the way. Moreover, as far as we have learned, the only sidecar combination that is in use in the European armies is the one arranged for carrying machine guns, and these have proved of inestimable value, for in many cases a small machine-gun motorcycle detachment has been able, by the rapidity of its movement, to take and to hold important positions where it was impossible to bring up an effective body of riflemen in time. A great number of these mobile machine gun batteries are attached to every division, and have been found indispensible.

For the transportation of machine guns a powerful and rugged motorcycle is required, and for this use our American machines are without doubt the best in the world, for it has been fully demonstrated that our motors are the equal in efficiency and power of any that have ever been produced, and the frames are superior in strength and rigidity to any foreign built machines, a result of our long experience in building for the rough roads found in many parts of this country. Another strong point in American machines is the ample road clearance, which is very important on the rutted and shell-furrowed roads in regions where active fighting is going on.

Besides their use in transporting machine guns the motorcycle has been found of great value for the carrying of despatches, and for this purpose solo machines are used exclusively abroad, and our information regarding them is mostly derived from British sources. When the war started the English authorities turned to their own manufacturers, and to secure a sufficient number of machines every kind available was taken. These included many small machines, running from 2¾ to 5 horse-power, and doubts were freely expressed as to the utility of these low powers, for everyone imagined the despatch rider as careering along, over shell pitted roads, and across rough fields, at racing speed. Experience, however, has changed all of these ideas, and it has been found that light machines of moderate power are best adapted to this important work. In the first place it is impossible to ride the rough roads at high speed, and the best results are had by steady plugging at moderate speeds, and great power is therefore not necessary. Moreover light weight was found absolutely necessary, because on the overcrowded roads at the front, the motorcyclist had to get out of the way of the transport trucks, or get run over, and to do this he had to take to the ditch, dragging his machine clear of the road. This and lifting it out of shell holes, up banks and over obstructions, requires some strength, and few men could survive a day of this kind of work handling a heavy, high-powered machine. The best motorcycle for despatch carrying is undoubtedly a single cylinder machine of from three to four horse-power, for it has ample power for its special work, it can be reasonably light, and most important of all, it is simple, and that means much where the rider must usually improvise his own repairs. The smaller English machines used at first have undoubtedly been unsatisfactory, and there has been serious trouble from broken frames and forks, and in this respect our motorcycles are undoubtedly superior.

The photograph on the first page of this issue shows an American despatch rider as he appears in maneuvers, and it will be seen that his mount is a big machine weighing, with equipment and fittings, in the neighborhood of 400 pounds, apparently a prohibitive weight in actual service. It will also be noticed that he is carrying a regulation rifle in a boot strapped to the front forks. Experience abroad has shown that it is impracticable and useless for a despatch rider to attempt to carry a rifle, and the only weapon carried in the European armies is a good automatic pistol.

The dare-devil despatch rider of the public prints, careering across country at racing speed, has disappeared, if he ever existed, and the present day courier is the steady-going, determined man who gets through in spite of every obstacle.

# The Brownian Movement of Electrified Particles in Gases—II*

## And the Charge of the Electron

Concluded from Scientific American Supplement, No. 2160, Page 323, May 26, 1917

By Dr. A. Schidlof

### V

THE CRITERION OF THE "CONSTANCY OF THE MOBILITY." INVESTIGATIONS OF E. SCHRÖDINGER AND M. VON SMOLUCHOWSKI

Before examining this question more closely it is indispensable to sound the theory of the method of observation. It is based on the application of the laws of probability to the statistical fluctuations observed. But it does not seem that one would be justified in applying statistical processes if the number of cases studied is not sufficiently large; and when might we consider the number large enough?

M. Ehrenhaft has believed that he could get around the difficulty by introducing the criterion of the "constancy of the mobility." He calculates the mean square of Brownian displacement per second successively for 10, 15, 20, 25 observations, and so on. In this way he rapidly arrives at constant figures and he concludes from this that the number of observations is sufficient to give the desired precision to the result. In reality this argument proves absolutely nothing.[32] Moreover, in a remarkable piece of work, E. Schrödinger[33] has calculated the probable precision of the result. The probable relative error is expressed by: $\frac{V\sqrt{2}}{m}$, $m$ being the number of observations. The probable error is therefore one of 20 per cent for $m=50$, of 14.2 per cent for $m=100$, and so forth.

The relatively short series of observations made by Ehrenhaft have therefore a very low degree of precision and do not permit calculation of the charge of the electron except with little certainty. Konstantinowsky has made a larger number of observations, which lead to a figure a little inferior to the exact value of $e$; the reasons for this disagreement will be examined later.

It is to be noted that only metallic particles, and particularly those obtained by electric pulverization lead to figures which are too small. H. Fletcher[34] and C. F. Eyring[35] have made a very large number of observations of the Brownian Movement of drops of oil in rarefied gases, and have obtained values of the elementary charge remarkably close to the number of Millikan. These authors, as well as Konstantinowsky, utilize for the calculation of results a formula due to Fletcher, based upon inexact reasoning. Schrödinger and almost simultaneously von Smoluchowski[36] have made the rigorous theory of the method and have proved that the formulas used in the beginning by Weiss are correct, and that the modification proposed by H. Fletcher should be abandoned.

Let us observe also that the terms of correction employed by Fletcher, of which the first term of the remainder is exact, have very little influence on the value of the result.

He is concerned here with simplifications of calculation almost inoffensive. The remarks of Schrödinger and von Smoluchowski, therefore, do not weaken the numerical results of Fletcher and Eyring.

### VI

RESEARCHES MADE IN THE LABORATORY OF PHYSICS AT THE UNIVERSITY OF GENEVA

Nevertheless, there remains the following difficulty: the figures resulting from the study of the Brownian Movement of metallic particles pulverized in the arc are notably inferior to the real value of the charge of the electron and though this divergence is not enough to justify the hypothesis of sub-electrons, it may, however, suggest doubts of the validity of accepted laws governing the Brownian Movement in gases. With the object of elucidating this question we have studied concurrently the Brownian Movement of drops of oil and of metallic particles to discover if possible the cause of these divergences.[37]

It is quite hard to collect a number of isolated observations sufficiently large to permit a searching discussion of results. Fearing to diminish too greatly the precision of individual observations, we have wished to utilize, at the suggestion of Fletcher and Eyring, a falling distance subdivided into very minute intervals, but we have always observed the fall through a length of at least 0.5 millimeters. Likewise, we have not made many observations in rarefied gases, these experimental conditions being capable of giving rise to multiple causes of error, particularly if one attempts to control the experiments by means of the law of Stokes-Cunningham.[38]

We have made in all 2,700 observations with drops of oil and 1,244 with metallic particles, but in a certain number of experiments the intensity of the Brownian Movement was too feeble to permit precise enough observations. After eliminating these defective experiments, there remain 2,267 upon the drops of oil and 1,050 upon the metallic particles. But all these observations lead on the average to a value of the charge of the electron approaching the number of Millikan to within about one per cent. We, therefore, have attained a precision superior to that foreseen by the theory.

The metallic particles, which are not certainly spherical, tend perceptibly to the same result as the drops of oil. Let us remark, however, that this confirmation is not true except for particles of tin and of cadmium, obtained by the processes indicated above. The particles produced by the voltaic arc furnish values notably inferior to the true charge of the electron for reasons which will be explained later.

### VII

THE LAW OF DISTRIBUTION OF BROWNIAN DISPLACEMENTS

Not content with proving the quantitative concordance of averages, we desired to ascertain whether the Brownian displacements of individual observations distribute themselves conformably to the theoretic law. This law, established by Schrödinger and von Schmoluchowski, does not lend itself to convenient calculation, but we have found that if one considers the quantity: $\xi=\frac{t-t_1}{V\sqrt{t}}$, in which $t$ is the duration of the individual fall, and $t_1$ the average of the duration of fall of a series, *then the absolute values of the quantities $\xi$ must distribute themselves according to the law of Gauss.*

If we multiply the quantities $\xi$ by a factor which depends upon the constants of the series under consideration (speed of fall, speed of ascent, intensity of electric field, number of elementary charges carried by the particle), we obtain a quantity $\psi$ of which the absolute values ought likewise follow the law of Gauss, with a theoretically given parameter whose value depends only upon universal constants and on temperature.[39]

The following table gives opportunity to compare the observed and calculated distributions for 2,267 observations made with drops of oil. The intervals $\pm\Delta\Psi$ are all of the same size, save the last, which extends to infinity, and corresponds on the average to variations of the duration of the fall of about $\pm$ 1 second.[40]

TABLE

| Observed Distribution | Calculated Distribution |
|---|---|
| 659 | 666.4 |
| 597 | 579.0 |
| 449 | 437.4 |
| 277 | 286.4 |
| 146 | 163.4 |
| 95 | 80.7 |
| 31 | 34.9 |
| 9 | 12.9 |
| 2 | 4.3 |
| 2 | 1.6 |
| 2267.0 | 2267.0 |

The fact that the observed Brownian displacements distribute themselves effectively according to the theoretic law is one of the best proofs of the identity of the elementary charges of gaseous and electro-chemical ions, for this proof no longer applies to averages, but causes individual observations to intervene.

It is true that the method is of very limited precision, but on the other hand it furnishes a demonstration which is in some sort objective, and consequently particularly conclusive, of the existence of an indivisible elementary charge.

The figures obtained for the metallic particle obey somewhat less well the law of theoretic distribution, and display an excess of large displacements, to which Targonski[41] was the first to direct attention; this defect manifests itself in a more accentuated fashion in the figures observed by Konstantinowsky and more still in the observations made with the coarser particles produced by the pulverization of metals in the voltaic arc.

### VIII

BROWNIAN MOVEMENT OF NON-SPHERICAL PARTICLES—CONCLUSIONS[42]

The study of the distribution of divergences permits us to prove, therefore, that only spherical particles conform rigorously to the theoretic law. As for the others, the coarser the particle the greater the divergence.

The theory cannot be rigorously applied to non-spherical particles; the theory is based, in fact, upon the supposition that the "mobility" deduced from the observation of the Brownian Movement is the same as that which takes place in the movement of fall and ascent. This cannot be true in general except for spherical particles; in the case of the others, the mobility of translation depends upon *the orientation of the particle.* But the orientation of a very minute particle changes continually as a consequence of the *Brownian Movement of rotation.* A very small body turns without cessation irregularly in every direction, and if its symmetry is not that of a sphere, the mobility of translation according to a given direction is subject to fluctuations susceptible to treatment by statistical methods.

It is evident that these fluctuations superpose themselves upon true Brownian displacements of the speed of translation and lead to a mean square of Brownian displacement which is too large, and consequently to a mobility which is apparently too great. This is the true signification of the fact noted by Targonski (see Chapter IV).

In the same way we can easily explain why this effect tends to disappear when the intensity of the true Brownian Movement becomes very great. If the particle observed is small, and if it present a form not particularly unfavorable it whirls so swiftly in every possible direction that the mobility of translation is perceptibly constant.

There results from this a pseudo-spherical symmetry of particles and the calculation leads to nearly the same result as if the particle were truly spherical.

This interpretation removes the last difficulty raised by the experiments made with particles pulverized in the voltaic arc. It is evidently better not to use these particles for the determination of the charge of the electron and of the number of Avogadro, but we see that, suitably interpreted, the observation of the Brownian Movement of these particles confirms the accepted theories. We have, moreover, found by the aid of very minute metallic particles the same value for the elementary charge of gaseous ions that Millikan obtained by means of a method peculiarly well chosen in every respect.

As for the number of Avogadro it cannot be doubted that the value deduced from the number of Millikan is the most exact known to us at present.

## Oriental Architecture in Reinforced Concrete

Mosques and other buildings are now erected in reinforced concrete in Egypt and other countries and adhering to the national type of architecture as regards the design of such structures. Among others we mention the Sultan Hassan mosque at Cairo, in which reinforced concrete enters largely. Another very handsome structure of Oriental type was recently erected near this city, the Grand Palace Hotel of Heliopolis. It is a vast building of four stories, and presents a pleasing aspect owing to the excellent architectural design inspired by the prevailing styles. All these examples are the French Hennebique concrete system.

## A Military Wireless Outfit

Wireless communication is destined to play an important part in warfare, and undoubtedly is doing so today, although comparatively little is heard of it so far. In this country the Signal Corps of the Army has recently acquired an unusually complete portable wireless outfit, which is believed to be the most powerful of its kind. The apparatus is mounted on a motor car chassis and can be set up complete and in operating condition in as short a time as twelve minutes. Under favorable conditions, the apparatus has a sending radius of up to 800 miles. Messages from points 2,500 miles distant have been received. The generator which furnishes the current is driven by the same motor that propels the vehicle. Antennæ of the umbrella type are used, the mast, which is in nine sections, being 85 feet in height.

*Revue Generale des Sciences.

[32] See A. Targonski, Arch. d. Sc. phys. et nat. l. c.

[33] E. Schrödinger. Phys. Ztsch. Aug. 1915, Vol. XVI, p. 289.

[34] H. Fletcher, l. c.

[35] C. F. Eyring, l. c.

[36] M. von Smoluchowski, Phys. Ztsch. 1915, Vol. XVI., p. 318

[37] A. Schidlof and A. Targonski, l. c.

[38] See, e. g., the objections raised by F. Zerner, (Phys. Ztsch., 1915, Vol. XVI, p. 10) against Fletcher's results.

[39] A. Schidlof and A. Targonski. Soc. de Phys. et d'Hist. nat. Geneva, May, 1916.

[40] In reality the intervals $\Delta t$ within which we group the individual durations of fall vary from one series to the other, and moreover, for the same series, $\Delta t$ depends on the duration of fall under consideration, and diminishes with the latter. We give the information above only by way of approximate information as to the limits of precision of the method.

[41] A. Targonski: Arc. des Sci. phys. et nat. (Geneva), l. c.

[42] A. Schidlof and A. Targonski: Soc. de Phys. et d'Hist. nat. Geneva, June, 1916.

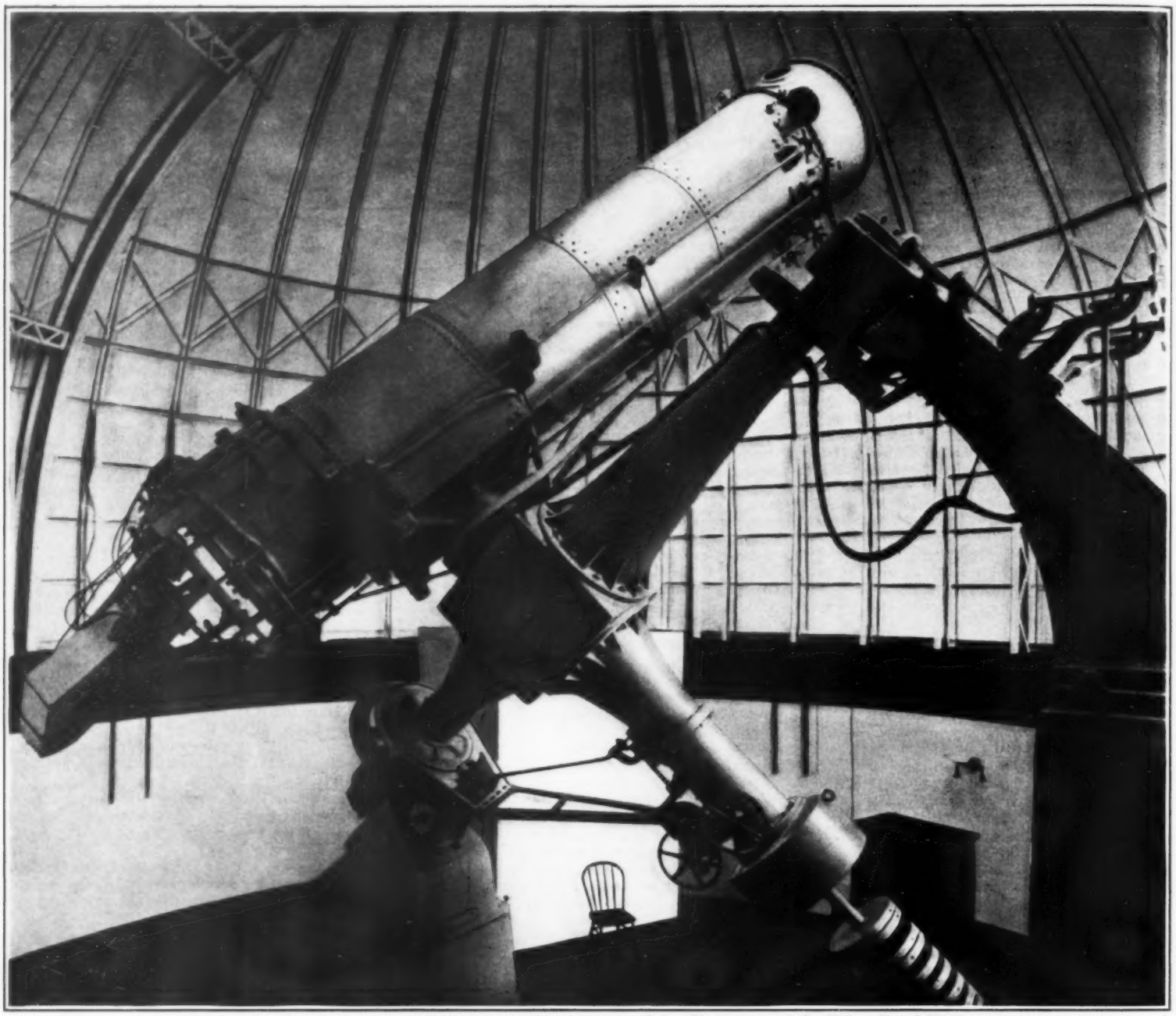


Fig. 1. The thirty-seven and one-half inch reflecting telescope of the Observatory of the University of Michigan

# Stellar Evolution

## The Discovery of a Missing Link in the Chain by Spectra Observations

R. H. Curtiss, Associate Professor of Astronomy, University of Michigan

One of the first generalizations drawn from extensive observations of stellar spectra was the recognition of a sequence in which there was a place for nearly every star examined. In the interest of convenience certain definitely characterized types in this sequence were chosen as a frame work for classification first by Secchi, later by Vogel, and by Lockyer, and lastly, on the most complete basis by investigators at the Harvard College Observatory.

The Harvard Classification of Stellar Spectra, using the letters O, B, A, F, G, K and M to designate the divisions, is adopted almost universally in this country, and is widely used in Europe. On the one end are placed white or bluish-white stars whose spectra show well defined nebular characteristics and on the other red stars whose spectra are marked by the absorption bands of compounds as well as by many of the metallic absorption lines found in the solar spectrum, which in the Harvard Classification is assigned to Class G. Practically all astronomers agree in the view that the sequence of letters in the Harvard Classification corresponds to stages of stellar development from the white hot, low density star on the one hand to the relatively cool red star on the other approaching a state of visual extinction, and that the divisions in the spectral sequence of the Harvard Classification serve as an index to successive physical states in the process of stellar evolution. Accordingly, an interruption in this sequence may be regarded as a missing link in the chain of stellar evolution.

Corresponding to a wider range of observation and increased knowledge the Harvard system of classification has been slowly extended to include more and more objects for some of which no previous provision had been made, so that now there remain outstanding only a few isolated cases or small groups of stellar bodies whose relation to the regular sequence is not clear.

Occupying a prominent position among outstanding groups of intractable objects are those stars whose spectra have been placed in a division called Class N by the Harvard investigators. In a recent Harvard tabulation 267 of these objects are found. They are all red stars. Among them no bright members are found. All of them are probably very distant and a large majority of them are located in the Milky Way. The spectra of these stars are very similar to those of Class M at the end of the sequence given above. The chief difference between spectra of Class M and Class N lies in the special absorption. Class M spectra contain wide absorption bands sharp toward the violet and degraded toward the red, probably due to titanium oxide; Class N spectra have similar bands, though reversed in appearance, being sharp toward the red, attributed to some carbon compound.

Since these carbon and titanium oxide absorption bands are usually conspicuous features in these spectra many investigators beginning with the earliest have held the view that the spectra of Class M and Class N should fall into two distinct groups, the first of which, Class M, appears to be attached quite directly to the spectral sequence. Other investigators have looked past the bolder features of the bands and have concluded from the resemblance in the remaining characteristics that these two types of spectra should be classed together as coördinate groups leading back to the sun.

Probably most astronomers have accepted this latter conclusion. But a serious objection to the proposal of coördinate branches leading back to the sun has been based on the fact that no examples of an intermediate type between the solar spectrum and Class N had been found though a complete sequence from the sun to Class M had long been established. There was evidence of a missing link in the proposed chain of stellar evolution connecting stars with spectra like that of the sun and those with spectra of Class N.

Not long before this time several unusual stars had been swept up in the course of the extensive spectral surveys which were under way at the Harvard College Observatory. These objects though placed in Class N, were found to be less red or more like the sun in color, than ordinary objects of this class. Later discoveries of stars with spectra of this kind increased the number

to the point where the addition of a new class was warranted. Accordingly Class R was created to include them. Because of the faintness of the Class R stars spectroscopists met with great difficulties in studying their spectra but there was evidence sufficient to suggest that the stars of Class R might supply the missing link between the sun and Class N stars.

At this juncture the new 37½-inch reflector (see Fig. 1) of the Observatory of the University of Michigan became available for research with its great light-gathering power. This instrument had been fitted with a slit spectrograph well suited to the analysis of faint spectra. Accordingly the study of the spectra of ten of the brightest of the Class R stars not too far south of the equator was undertaken at this Observatory. The investigation was assigned to Mr. W. Carl Rufus who developed the study into a thesis accepted in partial fulfillment of the requirements for the degree of doctor of philosophy in the University of Michigan, and published in Volume II of the Publications of the Observatory of the University of Michigan.

The results of this study of the spectra of Class R stars can be set forth best in a non-technical journal through the accompanying illustration. (See Fig. 2). In this the spectrum of our sun is placed at the top and a standard Class N stellar spectrum at the bottom. Between these are ranged in a sequential order eight Class R and Class N stellar spectra showing successive steps in the transition from the solar spectrum to that of a standard Class N star. The first of these Class R spectra is quite similar to that of the sun immediately above it in the illustration. The chief difference between these two spectra consists first in the relatively greater faintness of the Class R spectrum on the left or violet end, due both to increased general absorption and to special absorption of cyanogen beginning under the letter "g," and secondly in the presence of the characteristic "carbon absorption band" in the Class R spectrum about one-third of the distance from the right or green end to the left or violet end. A little lower down in the series absorption due to carbon appears beginning almost directly under the symbol "λ4405." These three bold features become more prominent as we proceed down the sequence until in the standard Class N spectrum at the bottom we have a short band of light in this region divided by a heavy black carbon band.

On the basis of the series of spectra shown here, and of others photographed at Ann Arbor, the fact seems well established that the spectra of Class R supply the missing steps between the spectra of Class N and the spectrum of the sun. And at the same time strong support is given to the theory that the two classes of red stars, Classes M and N, are coördinate groups leading back to the sun. If this convincing evidence be accepted, the relation of Class N through Class R to the spectral sequence is defined; a gap is closed in the order of stellar spectral classes; and in the Class R stars is found a missing link in the evolutionary chain which is thought to be formed by the successive stages in the life of a stellar body. The stellar evolutionary chain in terms of the letters denoting the divisions of the Harvard Classification of stellar spectra may be indicated by the following arrangement of symbols with the new link, Class R, introduced:

[redacted]—X—' ⟋ R-N(Dark stars)
(Nebula)—O-B-A-F-G(Sun) ⟍ K-M-(Dark stars)

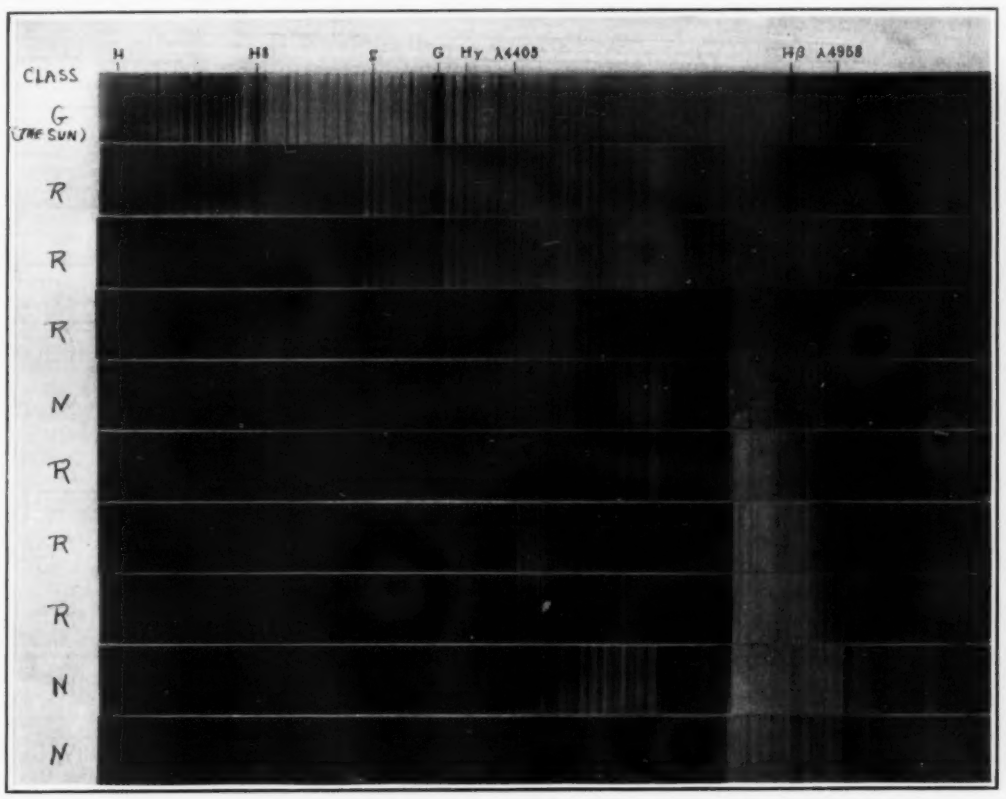



**Fig. 2. Stellar spectra, showing steps in evolutionary sequence from the Sun (Class G), to the standard Class N star**

# Maintenance of Management

## The Most Important Element of Waste Elimination

By Frank B. Gilbreth, Mem. Am. Soc. M. E.

A most important element of waste elimination is *maintenance of the best that is known*. Achievement in the successful installation of new features of management depends more upon *maintenance* of the best than it does upon WHAT has been installed and HOW the component parts have been introduced or WHO has been taught. The work of changing management, or of installing new management, demands five things:

1. Knowledge of the underlying laws of management.
2. Procedure for determining methods of least waste.
3. The least wasteful sequence of installation of features of Modern Management.
4. Procedure for teaching the methods of least waste.
5. Maintenance of standards.

Too often there is a tendency to consider that a successful demonstration is all that is needed to prove the completeness of the efficiency of the new method. In reality, unless the desired features are maintained permanently, there is little likelihood of a return of benefits sufficient to pay the cost of installation. The purpose of this paper is to show a method that will assist in handling the problem of maintenance, by describing in detail the making and the use of the "Standing Order."

There are various requirements that a Standing Order must fulfill if it is to act as a maintaining force. (1) The first requirement in the process of maintenance is a clear understanding in the mind of the management as to WHAT we wish to maintain. The best way to insure and to perpetuate this is to put it in writing. The subject matter of the standing order may then be considered and used as "of the essence of the contract" between the employer and the employee, in determining whether or not the high rate to be paid only upon the fulfillment of the terms of the Standing Order, has been earned.

2. The second requirement of a Standing Order is a recognition of WHY the thing required is to be done. In the course of time, the file of Standing Orders naturally becomes voluminous; consequently, no one can be expected to remember them all. In fact, in many cases, it will be difficult to remember even all of those that affect one's own line of promotion. Yet, the more that are remembered by all, the better will be the result, We have found during a continuous experience of 20 years of using written Standing Orders, that the more the WHY is inserted in the Standing Order, the easier it is to remember it. Furthermore, it is more natural for one to coöperate heartily toward the desired end when one sees the reason, the purpose and the underlying motive of the Standing Order.

3. The third requirement is a clear statement as to WHO is responsible for the order. Oftentimes the subject matter of a Standing Order is perfectly clear in the mind of the one who suggested it, but it is not clear as written on the Standing Order form. Therefore, what is in effect a Standing Orders Committee passes upon each Standing Order. This committee consists of:

a. The suggester of the idea in its original form. (The original form may be quite different from its effective, or final, form.)

b. The suggester of any previous Standing Order that it affects.

c. The approver of all Standing Orders. This man should be one who has sufficient grasp on the subject matter of all Standing Orders to understand the effect of the additions or changes that the new Standing Order will have.

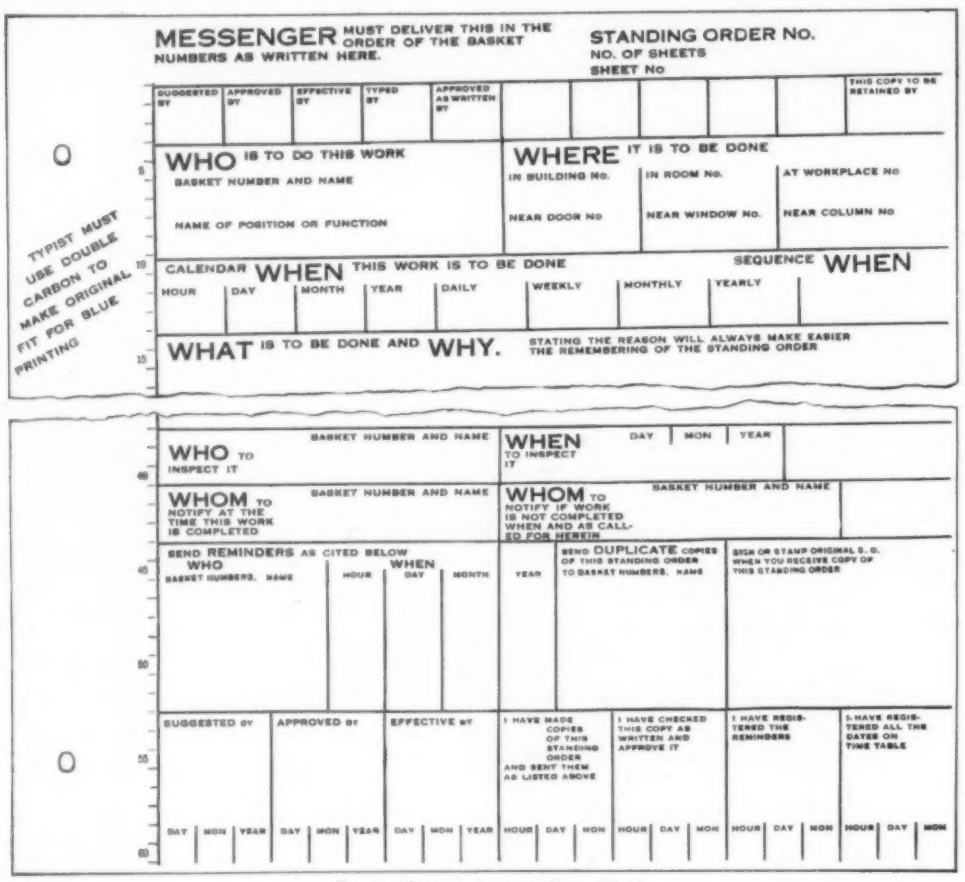
d. The decider who makes the Standing Order, as written, effective or void. He should be the best man obtainable, one who is willing to have his measure taken by his decisions and to take the glory or blame of his decisions.

The committee is supplemented in the following manner: Many suggestions for new Standing Orders seem admirable when considered separately but show themselves calamitous when considered with others. Therefore, no Standing Order should be made effective until it is passed upon by certain individuals who are specially informed about and affected by the Standing Order. A list of such persons as are to receive a copy of the Standing Order should be cited immediately after it has been made effective, if not before, that the approver or decider, either or both, may confer with highly trained experts in the particular field of knowledge or work, before committing themselves to a decision or to a signature.

Every one who receives a duplicate copy of a Standing Order is expected to coöperate toward making it a success if possible, although it is his privilege to record in writing his objections to, or criticisms of it; in other words, those in this list compose a secondary committee, in case a new or changed Standing Order should be made effective. In case of any objections, it is their duty to remonstrate with the decider or approver, or others of the secondary committee, until the matter of their protest has been thoroughly passed upon. Every opportunity to hold up a detrimental Standing Order, or to make it void before it actually gets into action, is thus provided for. In order to insure the services and judgment of experts also at the time when the subject matter of the Standing Order is actually to be performed, the Order contains space for reminding "to do," "to supervise," and "to inspect" the work. These are issued at certain times, such as:

a. The right time before.
b. During.
c. At the time set for the completion of the work called for in the Standing Order.

Here again we have the attention of the specialized expert at just the time when his knoweldge, skill and experience is most valuable, with the least amount of time wasted in waiting.


MESSENGER MUST DELIVER THIS IN THE ORDER OF THE BASKET NUMBERS AS WRITTEN HERE.
STANDING ORDER No.
NO. OF SHEETS
SHEET No
SUGGESTED BY
APPROVED BY
EFFECTIVE BY
TYPED BY
APPROVED AS WRITTEN BY
THIS COPY TO BE RETAINED BY
TYPIST MUST USE DOUBLE CARBON TO MAKE ORIGINAL FIT FOR BLUE PRINTING
WHO IS TO DO THIS WORK
BASKET NUMBER AND NAME
NAME OF POSITION OR FUNCTION
WHERE IT IS TO BE DONE
IN BUILDING No.
IN ROOM No.
AT WORKPLACE No
NEAR DOOR No
NEAR WINDOW No.
NEAR COLUMN No
CALENDAR WHEN THIS WORK IS TO BE DONE
SEQUENCE WHEN
HOUR
DAY
MONTH
YEAR
DAILY
WEEKLY
MONTHLY
YEARLY
WHAT IS TO BE DONE AND WHY.
STATING THE REASON WILL ALWAYS MAKE EASIER THE REMEMBERING OF THE STANDING ORDER
WHO TO INSPECT IT
BASKET NUMBER AND NAME
WHEN TO INSPECT IT
DAY
MON
YEAR
WHOM TO NOTIFY AT THE TIME THIS WORK IS COMPLETED
WHOM TO NOTIFY IF WORK IS NOT COMPLETED WHEN AND AS CALLED FOR HEREIN
SEND REMINDERS AS CITED BELOW
WHO
WHEN
SEND DUPLICATE COPIES OF THIS STANDING ORDER TO BASKET NUMBERS, NAME
SIGN OR STAMP ORIGINAL S. O. WHEN YOU RECEIVE COPY OF THIS STANDING ORDER
SUGGESTED BY
APPROVED BY
EFFECTIVE BY
I HAVE MADE COPIES OF THIS STANDING ORDER AND SENT THEM AS LISTED ABOVE
I HAVE CHECKED THIS COPY AS WRITTEN AND APPROVE IT
I HAVE REGISTERED THE REMINDERS
I HAVE REGISTERED ALL THE DATES ON TIME TABLE

**Proposed form for standing order**

4. The fourth requirement is the statement as to WHERE the work is to be done. This place is determined and located accurately so that those who are to do the work may visualize the place where it is to be done when they first receive the reminder file card notifying them to proceed to the workplace. This, of course, presupposes that the buildings, workplace, doors, windows and columns have been classified and assigned symbols and numbers according to a logical routing system that has been developed from measured data.

5. The fifth requirement is that of stating WHO is to do the work of the Standing Order. The WHO may be a definite individual, or the WHO may be the one who happens to be responsible for a certain function or position at the time, or even the person acting in that function temporarily. By this means the WHO is taken care of, regardless of the changes in the personnel, or temporary absences,[1] and the carrying out of the Standing Order is insured.

6. The sixth requirement is that of providing for WHEN the work is to be done. To save writing the "day," "week," "month," and "year," "daily," "weekly," "day," "week," "month," "year," "daily," "weekly," "monthly" and "yearly" spaces are provided for, if the work is to be repeated at definite times, or definite intervals. If its time of execution is dependent upon some other work to be first completed, the WHEN is provided for in the space left for "sequence when." It should be observed also that insistence upon definite planning and assigning a definite WHEN will have many and important bearings upon maitenance of the Standing Order, and many important by-products as a result.[2]

7. The eighth requirement is ample provision for *inspection*. Inspecting what we do, the firm belief that what we are to do will surely be inspected, and that promptly, causes us to work with greater speed and accuracy. Therefore, each Standing Order must provide for:

a. WHO the inspector is to be.

b. WHEN he is to inspect.

c. WHOM he is to notify if the Standing Order has not been carried out *as*, and *when*, called for.

d. WHOM he is to notify if the work has been completed *as*, and *when*, called for.

General standing orders provide that the one in charge of the Master Time Table check the receipts in turn, or check the returns from the Inspectors. Here we have a definite means for furnishing the information for charting the output and omissions of individuals; also a most practical working of the "exceptional principle" in management; namely, if events pass as called for in the Standing Orders, those high up in the organization do not have their time taken up in attending to expected routine. While, if these things are not done as planned, the Standing Order calls the attention of the certain executives or their assistants, on the exception principle, to necessary changes.[2]

The eighth necessity is for provision for recording while the Standing Order passes through the various stages. It is important that they become a matter of routine and that they are put into the regular channel of the system as rapidly as possible. If there are to be several copies, one person should be held responsible for their agreeing. It is also important that they be written promptly after they have become effective. Therefore, a place on the form for recording the time that it was suggested, approved, made effective and duplicated, should be provided at the bottom of the sheet.

The ninth necessity is provision for notification. The typist should write, in logical order, at the top of the sheet, the Basket Numbers or Workplace Numbers of the persons who are to receive copies, or who are, at least, to read it. The persons who receive copies, sign or stamp their names in the places provided, to show that they have been properly notified.

It is expected that each of the Standing Orders is sufficiently important to warrant rereading in final form,

a. By the suggester, that he may see that his idea has been incorporated clearly in the Standing Order, and that he may have a final chance to see if it embodies his complete idea, or improve it, before it becomes effective. There are many benefits accruing from this procedure. For example, the recording of the names of the suggestors on the Standing Orders gives the supervisor of promotion valuable records of those who possess an exceptionally good grasp of the situation.

b. By the approver, that he may see the suggestion in its final form.

c. By the one who makes it effective, that his second thought may still be that this Standing Order shall be what its names implies, a written order that stands effective in all its details until cancelled or changed by a Change Order in writing.

d. By the reminder file clerk, who must see to it that he may check the reminder slips that he receives with it.

e. By the maker of the Master Time Table, that he may set down each stipulated time when a return or report is due, that notifications may surely be made promptly, and that the Inspectors also may be inspected if they do not carry out the Standing Order literally.

[1] See "Three Position Plan of Promotion"; "The Annals," May 1916.

[2] See "Psychology of Management," Chapter VII; Sturgis and Walton, New York.

[2] See "Graphical Control on the Exception Principle for Executive." Transactions Amer. Soc. Mech. Engineers, 1916.

The form herein shown was designed gradually, as a result of practice. This particular form is not absolutely essential; in fact any form, even an ordinary typed sheet, or a cuniform brick, will serve the purpose, if it be in writing and has the features herein listed.

The amount of time spent in establishing the process outlined in this form once and for all may seem large to one not acquainted with the speed with which such work is carried out, once the procedure has been made plain. This procedure is also covered by "Standing Orders for Installing Standing Orders"; but it must be noted that this order so thoroughly functionalizes the work that no one is expected to put in more time upon it than that of actually doing productive work. This means that the time of the executive higher up, that, under ordinary conditions, is wasted in straightening out clashes and disorders that come from different methods on similar work, is hereby saved; that a general lack of systematic notification is supplied; that a definite plan for encouraging and using suggestion is installed; and that a definite method for securing coöperation becomes effective. There is much and valuable talk today about doing away with things that are wasteful and ineffective, but in this general and necessary destructive process the need to conserve and maintain that which is good must not be overlooked. It is often thought abroad to be an American trait to be unsystematic where maintenance of the best is the problem in question. We are noted throughout the world for our ability to invent and discover new and wonderfully ingenious devices, machines, and methods, and to install these rapidly and effectively. We are, however, often thought at fault in allowing our discoveries and installations to lapse, in our desire for, and search for, something newer and better. We see this ourselves in our road building, in our construction, and also, sad to relate, in our educational and surgical practices. In fact there are few lines of activity where maintenance is not sadly lacking today. The benefit of installing such maintenance, practice and insurance as here outlined is, then, in the final analysis, not only simply an increase in the element of maintenance in the particular plant or industry, but also is a permanent object lesson in the possibility, practicability and ease of maintenance.

Engineers have been great inventors and installers. It is with the hope that they may also become and remain preëminent in the field of *maintenance of the best that is known*, that this paper is offered. In the hope also that it may prove a stimulus for a long series of such papers covering maintenance in various fields of activity.

## Coloring Copper

COPPER lends itself readily to coloring processes, and may be worked to all shades imaginable, excepting the lighter shades, which are lost on a copper surface, as that metal cannot be given a tint lighter than its natural color.

Copper can be carried through the entire range of shades, from a very light copper color to the darkest brown, or even black, by merely oxidizing the surface of the metal. Make a paste of iron oxide and graphite, with alcohol (wood) or with plain water (the alcohol dries out quicker and allows the process to be hastened), then heat the article in an oven or over a gas flame. The color obtained will depend on the amount of iron oxide mixed with the graphite, and the length of time the heat was maintained. The more iron oxide in the coating the darker the shade given to the copper.

The remains of the coating should be removed by a brush or cloth moistened with alcohol, and when the surface has become quite clean, protect the color by applying varnish, lacquer, or pure wax, which may be laid on with a brush while the copper is heated. Some brown colors are obtained by using a mixture, as above, of verdigris, salammoniac, and vinegar, using two to three times as much of the verdigris and salammoniac as of the vinegar. The heat treatment is the same as in the preceding paragraph, and the color obtained can be made very much darker by adding some blue vitriol to the solution.

A red-brown may be given by using a vinegar paste containing equal parts of verdigris and cinnabar, together with two and a half times as much each of salammoniac and alum. The heat treatment is the same as for the other coatings.

A wide range of colors, comprising shades from a blue-black to blue-grey, may be given to copper by dipping in a hot "liver of sulfur" solution and then washing thoroughly, re-dipping or scratch-brushing and again dipping and washing, according to the tint desired. This must be learned by experience. Much information can be gained by taking some of the solution and some small pieces of copper and experimenting.—*The English Mechanic.*

# The Relation of Lighting to Architectural Interiors*

## Where Special Study is Necessary to Realize Ideals

By Morgan Brooks

At first it appears surprising that an architect who has successfully produced a beautiful interior should relegate the lighting thereof to an uninspired subordinate, or even leave it to chance, with results often so inharmonious as to obscure his art. Doubtless this is partly due to the fact that the architect did not visualize his illumination with his interior plan, and will not or cannot give it afterthought, and partly because he is not seriously disturbed by the incongruous lighting of an interior which appeals to him as beautiful with or without light, so powerful is his original idea. Probably one specially trained in illumination, who has artistic perceptions, and is eager by skillful lighting to point out to others the beauties of an architectural design, and to soften any defects, will obtain better results than could the architect himself.

It has been customary enough for architects to design their specially built gas and electric fixtures, but it will be agreed that, as a rule, the harmoniousness of these fixtures is felt more by day than by night. There is a certain antique conventionality inherent in a porcelain-candle miniature-lamp design that makes it hopeless to derive therefrom adequate modern flood lighting.

The rapid advance in lamp making which gives us powerful units also necessitates new methods of indirect or concealed sources to avoid glare. Yet possibly the successful attempt to introduce light from nowhere has outdone itself, as the logical mind is baffled by the absence of a source of light.

Not only is it a satisfaction to know whence light emanates, but it is artistically pleasing to have illumination non-uniform. Indeed non-uniformity is a neglected means of success in architectural appreciation by light. When we admire a cozy-corner in a home, its attractiveness results from its being set apart from the rest of the room by its furnishings. A table lamp with an attractive shade provides good illumination but over only a limited area. Take away the table lamp and flood the corner with superfluous light and all coziness is gone.

In a similar manner much of the artistic taste in the design and furnishing of a room is nullified by immoderate or by monotonous lighting. When a room is completely lighted it is grasped at a glance, and maintains no interest. If only the center table is illuminated, there is opportunity for the play of the imagination in the darker spaces, and the room appears larger. Of course, if the entire room is to be occupied, as is a concert hall, it must be completely lighted; but even here the effort to obtain uniform illumination may result in diminishing the attractiveness of the room. Given a concert hall that is unduly long, with a platform at one end and entrances at the other: if evenly lighted the first glance discloses the full length of the hall and the extreme distance to the platform from the rear. Now let the stage be overlighted, the center only moderately lighted, and let the rear, under the balcony, have an intermediate illumination. On entering, the stage is conspicuous, and the middle portion of the hall loses a few rows of seats, bringing the rear seats decidedly nearer to the stage. Of course, the differences must be skillfully managed to show no sharply dividing lines, and the minimum must be up to program-reading standard. When such irregular illumination has a valid psychological basis it proves acceptable, although often unnoticed. To diminish the length of a hotel corridor this scheme of graded lighting is inadequate; but if the mid-length is well lighted especially by visible lamps, while the portion beyond is less brightly lighted and from concealed sources, the ordinary vision hardly goes beyond mid-length.

To take another case, a wide room will appear longer when the side walls are illuminated more than the ends, which then recede. The effect is enhanced if the ceiling-wall line is somewhat indeterminate, as the eye judges not merely by illumination but also by geometrical outline. Experiments show that a difference of the order of 10 per cent. may be produced in the apparent distance of a wall by altering its illumination.

Photographic art teaches us that pleasing contrasts may be produced by proper management of light, suggesting possibilities in artificial lighting of interiors often artistically superior to that of daylight. Fairly bright illumination is necessary to bring out a color scheme, while if form alone is to be shown, contrasts may be increased or diminished by throwing more light on the brighter surfaces or on the darker. In this way desirable contrasts may be enhanced, and undesirable ones subdued. Thus to display a colonnade the columns should be accentuated by illumination if naturally bright; but if dark, should be silhouetted against a well lighted background. Shadows should be produced. For extreme conspicuousness they should be made to run quartering by a 45 degree position of lamps. On the other hand objectionable pillars can easily be made inconspicuous, if they are rectangular, by dimly illuminating their surfaces to agree with a dull wall behind. In the case of round columns only perfectly diffused lighting will cause their rotundity to merge into the background. Pilasters, always an architectural embellishment, should be brought out by throwing their projecting sides into comparative darkness.

Any artistic feature of a house, such as an oil painting, a choice bit of furniture or a handsome stairway may be emphasized by superior illumination, just as a masterpiece of sculpture in an art gallery is specially lighted. Care must be taken, however, not to overdo this, or an exaggerated theatrical spotlight effect may result. These effects depend wholly upon relative illumination, and are equally possible with dim or brilliant general lighting. The beauty of a landscape is enhanced at sundown by the lengthening shadows of directed but diminishing light. Modern powerful high-efficiency lamps tend toward a lavish use of light often in entire disregard of artistic proportionality, imitating midday glare.

Psychological as well as artistic considerations suggest varying the illumination progressively for one entering a house. Finding the vestibule brighter than the entrance steps, the hall brighter than the vestibule, and the reception room brighter than the hall, a guest is insensibly directed by the increasing light in a hospitable manner. Where a valid reason for illumination differences exists, dependent on the use and the relative importance of the various rooms, pleasure is felt in the lighting interpretation, even when the means are not recognized. When the conditions are disturbed, perhaps merely by failure to replace a burned-out lamp correctly, the discord is felt by one at all sensitive to harmony in illumination.

Much thought is required to adapt lighting to the varying uses of a house. The best preliminary to lighting plans is to make an imaginary tour of the building with its owner or occupant, asking what the color scheme will be, what vistas must be kept unobstructed, the purpose of this room and that, and how they will be furnished. Beginners in illumination often overlook the light absorption by dull portieres and furniture, which darken a room. The quantity of light required increases with surface area. A rectangular desk shoved into a corner adds nothing to the room surface, but if set out in the middle of the room all its vertical sides are additional. Thus, in a public library, book stacks often more than double the area requiring illumination.

A good example of alternative lighting of a room adapting it to different demands, is seen in the flood lighting of a hotel dining-room for use at a general banquet, and in the cozy table-lamp transformation with meager general illumination, when it is desired to provide as many separate tables as possible for private parties. Indeed, the manager of a large hotel remarked that when the dining-room was thus lighted it was surprising how loudly the guests talked, as if no one were within hearing! Similarly a public reading room may have table lamps suggesting a privacy conducive to study, or may have the blaze of general lighting satisfactory for desultory reading, points of view justifying the combination of both methods.

Completely diffused lighting is wearisome, as evidenced in "white kitchen" restaurants, and there is one advantage in partially directed light not always recognized. Eye fatigue is relieved by change in illumination which causes a change in the adjustment of the eye muscles. When reading by direct light a slight movement of the paper produces such relief, perhaps unconsciously; but with diffused lighting no relief is possible. This explains why in inverted lighting the effect is better with relatively dark walls, as they absorb the horizontal rays, and the light comes only from above.

The well known unsatisfactory combination of artificial illumination and daylight is in part due to the mingling of horizontal and vertical rays, although color difference is also important. Architects avoid cross window lights, yet often specify strictly bracket lighting for a room, with brackets on every wall. When all are in use simultaneously there is objectionable cross-lighting and glare.

Freedom may be urged in placing of fixtures unsymmetrically except in rooms of extremely formal symmetry. Doors and windows are seldom regularly placed. Furniture must be arranged with reference to doors and windows; why not locate lighting fixtures with direct relation to the furniture? In factories utility governs location. In an artistic interior appropriateness governs, and this includes use as well as beauty.

Since the common arrangement of inverted lighting produces symmetrical and almost uniform illumination, it may seem that the artistic variation proposed would demand a return to direct lighting with its glare. It is true that extreme differences may require direct lighting, but semi-indirect and even direct lamps may be made much less diffusing than usual. There is opportunity in the development of oval or even boat-shaped bowls in semi-indirect lighting for sending out most of the light laterally. Moreover, it is possible to design one side of such elongated bowls for superior brightness, without diminishing their artistic appearance, and thus give the unsymmetrical light distribution suited to special needs.

A new method of directing inverted rays is found in a grooved ceiling. The resultant distribution depends upon the lamp reflector as well as on the shape of the grooves. With V-shaped grooves the locus of maximum floor illumination is not directly under the fixture but is an ellipse with major axis transverse to the direction of the grooves; while, strangely enough, loci of lesser illumination are elliptical figures whose major axes are longitudinal. With a V-ceiling a single row of inverted lighting units placed somewhat nearer together than usual, will serve a wider room than with a smooth ceiling. Also the brightness of the ceiling immediately over the lamp is reduced. A grooved ceiling will direct downward much light that is now wasted on upper walls, but the use of such a ceiling is suggested for directing light rather than for economy. Since distribution from a grooved surface depends on the shape of the grooves, independently of their size, the grooves may be minute, when the appearance would not differ noticeably from the usual ceiling. Such markings can probably be impressed upon fresh plaster at moderate expense, and in steel ceilings it is evident that fine grooves can be manufactured if demanded.

Whether these means or others are adopted, there should be a reaction from the too complete diffusion of modern inverted lighting, with appreciable gain in artistic effect.

*A paper read before the Illuminating Engineering Society, and republished from the Transactions of the Society.

### Lights in Gas-Charged Rooms

It has been shown by experiment that high candle-power electric lamps are dangerous in rooms where the atmosphere is charged with inflammable gas, for if the bulb is broken an explosion is almost certain to occur. Tungsten lamps ignited the gas in 25 to 85 per cent of the tests. The 8 candle-power 220-volt carbon incandescent lamp, however, caused only one ignition in twenty tests, and this was a test made by breaking the tip from the bulb and allowing the gaseous mixture to enter in a small stream which did not break the filament. For additional safety, it is recommended that wiring for electric light where gas is present should be installed in iron pipe conduits. If switches are used where gas is liable to be present, the switch boxes should be made gas-tight. As an additional safeguard the incandescent bulbs may have heavy glass outer globes and metallic shields outside.

### Examination of Coking Coal

The organic or active portions of bituminous coal as they occur in unaltered form are the portions that particularly effect its coking properties, but heretofore methods of analysis have not taken them into account in estimating the value of coal. It has now been found by the University of Illinois that phenol at 100 deg. C., will dissolve out certain constituents of bituminous coal in their natural state, a process that can be used quantitively, and it is also learned that the extract is the vital constituent concerned in the coking of coal. These experiments were conducted by Messrs. Parr and Hadley, and are described in the University Bulletin of November.

## Indicating Gear for Internal Combustion Engines*

We recently had an opportunity of inspecting in operation a new form of indicating apparatus which has been designed and patented by Mr. A. Ryder, the Laurels, Greenbank, Northwich. Mr. Ryder has charge of a large number of gas engines at an important chemical works and experienced the necessity for some form of indicating apparatus by means of which he could obtain diagrams from the cylinders of his engines without stopping them and thus interfering with the processes in the works. Usually the indicating gear requires fixing, or if already in position, an attachment to the piston of the engine has to be made which entails stoppage before diagrams can be taken, and finally another stoppage may be required to detach this gear. In any case, a stoppage is necessary to fix the indicator cocks. The indicating holes are long, as they have to pass through the outer casing of the water jacket, the jacket space, and the cylinder wall. These holes are usually filled up with plugs when not in use for indicating purposes; otherwise they may, and often do, contain a slow-burning mixture left from a previous explosion which causes pre-ignition of the charge and, possibly, serious consequences.

Mr. Ryder's invention consists essentially in a means of mechanically reproducing the path of the piston to a suitably reduced scale, the appliance being always connected and ready for use, although not permanently in motion. It consists further of a device by means of which the necessity of stopping the engine to fix the indicator cocks is avoided. With the above objects grooved eccentrics, corresponding to the cranks of the engine, are fixed on one end of the crankshaft. They are keyed in correct phase with the cranks, and the throw of the eccentrics corresponds with the length of the diagram required, or if the engine be of the high-speed type this may be reduced to one-third or one-half of the length so as to reduce the inertia of the lever or plunger. The circular motion representing the paths of the cranks on a reduced scale is converted into linear motion representing the paths of the pistons.

The application of the apparatus to a six-cylinder engine with three cranks is shown diagrammatically in Fig. 1, while the gear by which the linear motion is obtained is shown in Fig. 2. In this arrangement the linear motion is obtained by light levers *A*, one for each crank of the engine, having their fulcrums carried by a bracket *B*, attached to the frame of the engine. On the end of each lever is fixed a small roller *C*, which engages in the groove of its corresponding eccentric, and is held tightly in contact therewith, when in action, by the tensions springs *D*. To the opposite ends of the levers the indicating cord is attached. At the extreme end of each lever is a hook with which a catch *E* can be engaged by simply pulling down the handle *F* attached to the indicator cord. These catches engage on the hooked ends of the levers, and any one or all can be thrown out of gear.

Directly above the longer ends of the levers are fixed two quadrants (Fig. 1), one at a convenient height, from which to couple up horizontal cords to the indicators of any of the top row of cylinders, and one similarly fixed for the indicators of the bottom row of cylinders. A single cord is generally used to connect the end of any of the levers to the lower quadrant; another line connects the two quadrants. Both these are permanently connected. The bottom end of the lower line is provided with a hook, which can be quickly changed from the shackle of one lever to that of another, and it will be noted that both quadrants are fitted with tension springs, which resist the downward pull of the cords and so keep them always taut. It is therefore obvious that, when the lower cord is coupled to any particular lever, a linear motion corresponding to the piston represented by the eccentric with which the lever is in contact, will be transferred to both higher and lower quadrants, and it only remains for a horizontal connection by cord to be made to enable diagrams to be taken from either top or bottom cylinder, acting on the crank to which they are indirectly coupled. The cranks are numbered 1, 2, and 3, and the levers are similarly numbered in the same order. By simply changing the bottom connection of the cord to another lever as before described, any vertical pair of cylinders may be indicated. It is possible by multiplying the vertical cords and quadrants to indicate any number of cylinders simultaneously, but in practice the whole set may be done quickly in the way described. From the above description it will be observed that the gear is only in action for the actual time diagrams are being taken.

The second portion of the invention is quite essential to the first, insomuch as without it two stoppages would be necessary, one to fix the indicator cocks, and another to remove them. This consists of metal plugs shown in Fig. 3, and one is permanently screwed into each cylinder. Through this plug *G* is a central hole contracted at the cylinder end to form a seating *H*, and enlarged and threaded at the outer end. A spindle, *J*, formed to fit the seating above referred to, threaded at the opposite end, and provided with a head and locknut, is screwed in the central hole in the plug, and when home closes the hole at the cylinder end. The central hole is larger in diameter than the spindle, and when the latter is unscrewed ⅜ in. a free passage *K* is opened between the cylinder and the side passage *L*, into the end of which the indicator cock is screwed. A suitable guard *M* is attached to prevent the spindle from being withdrawn too far. A second passageway *N* is provided, communicating with the passage *K* leading to atmosphere, and closed with a one-way valve.

It will be seen that by simply unscrewing the spindle until the head is in contact with the guard, a communication has been made between the cylinder and the indicating cock, without stopping the engine. On the compression, firing, and exhaust strokes, the passage *K* is filled with gas under pressure, but on the suction stroke the one-way valve *O* automatically opens, admitting air which scavenges the passage, thus removing accumulations of gas, burnt, unburnt, and burning, or any glowing particles which might cause pre-ignition.

The combined apparatus, we are informed, has been in use on two six-cylinder 750 brake horse-power internal combustion engines for over eight months, has given perfect satisfaction, and has often been the means of quickly locating defects. An illustration of this feature may not be out of place. A rather bad case of pre-ignition has recently been experienced. An indicator diagram taken at the time is reproduced in Fig. 4. Not only was the fault located, but from the diagram it was not difficult to deduce the cause. It will be observed that the firing point of the pre-ignited charge coincides with the firing point of another cylinder, and so it proved to be when the wires were tested. The spark which was the cause of the pre-ignition should have fired No. 3 bottom cylinder, but owing to faulty wires was actually firing No. 2 top on the compression stroke.

When we had an opportunity of witnessing the operations of this invention, we were much impressed by the speed with which the diagrams could be taken from any of the six cylinders of a vertical engine without in any way interfering with its continuous working. For large gas engine installations where stoppages are few and at long intervals such an appliance should be very acceptable, as it enables the engineer in charge to ascertain whether each unit of his plant is doing its share of the work, and if not, enables him to diagnose the cause of the trouble.

*From *The Engineer*.

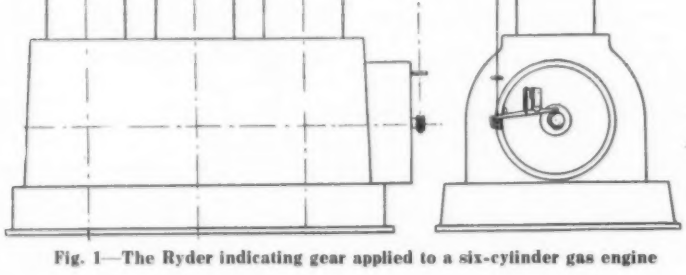


Fig. 1—The Ryder indicating gear applied to a six-cylinder gas engine

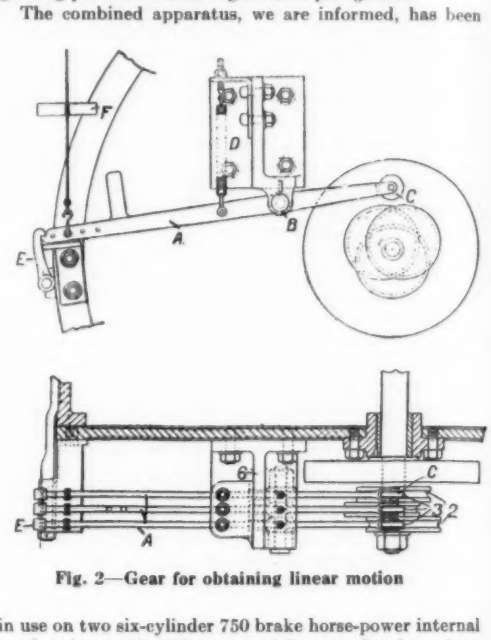



Fig. 2—Gear for obtaining linear motion

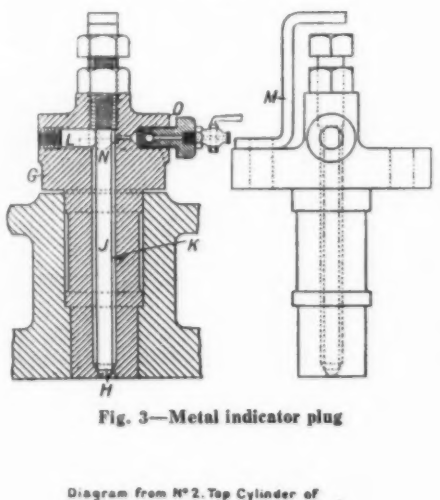



Fig. 3—Metal indicator plug

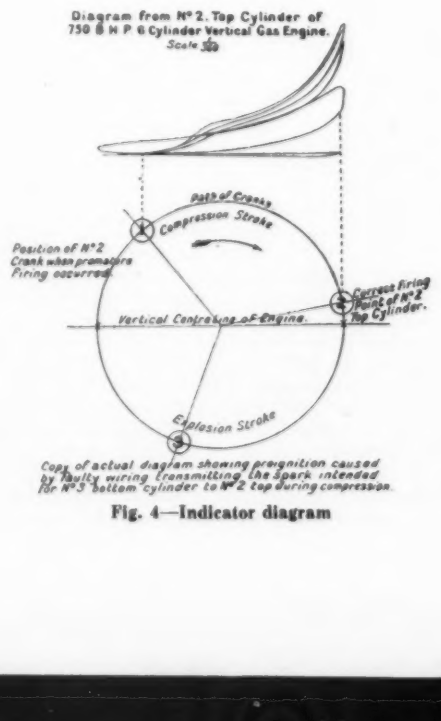


Diagram from N° 2. Top Cylinder of
750 B H P 6 Cylinder Vertical Gas Engine.
Scale
Path of Cranks
Compression Stroke
Position of N°2
Crank when premature
Firing occurred.
Correct Firing
Point of N°2
Top Cylinder.
Vertical Centre Line of Engine.
Explosion Stroke
Copy of actual diagram showing pregnition caused
by faulty wiring transmitting the Spark intended
for N°3 bottom cylinder to N°2 top during compression.

Fig. 4—Indicator diagram

## A French Submarine Motor

Of all internal combustion engines other than those of the true Diesel type the nearest approach to the Diesel cycle is that of the Sabathé motor, which is one of the oil engines adopted by the French government in their submarines, says the *Motorship*. This engine operates both on constant volume and constant pressure. It is mainly of the four-cycle Diesel type with compressed air injection, and the atmosphere in the working cylinders is compressed to about 450 pounds, as with the ordinary Diesel design. However, there is a double needle valve. The first part of the needle lifts and admits a small part of the fuel into the cylinder and combustion commences. As the needle lifts projecting pieces of metal lift the main valve and the balance of the fuel is admitted, the air-blast being used in both actions. Fuel consumption lower than that of any other design of oil engine is said to have been obtained with the Sabathé motor.

# The Mathematics of Warfare*

## How Trigonometry and Calculus Are Canned for the Gunner's Convenience

By J. Malcolm Bird

THE mathematics of warfare is a large subject, with many ramifications; and I shall be able only to identify some of these, and pursue them long enough to indicate the general directions in which they lead. But first I must point out one feature common to almost all war-time mathematics.

Every teacher has at one time or another consoled a student with the remark that while he has plainly made a numerical error, his method is correct. On the field of battle we should have to put it the other end to—that while his method seems correct, he has made a numerical error that renders his result worthless. Perhaps we would also have occasion to observe that he has taken so long to get the answer that even if it were correct the enemy's movements in the meantime would have made it obsolete.

I need not go into argument and example to indicate that the war-time mathematician must usually furnish a prompt answer as well as a correct one. But the field problems of warfare are mainly concerned with the flight of a projectile or the distance and direction of a fixed or moving object. In the one case differential equations are involved, in the other solution of triangles. Now nobody ever lived who could handle differential equations or solve triangles rapidly enough for his results to be of value to a waiting gunner. So most of the mathematics of warfare have to be worked out in advance, and canned for future use in the form of automatic registering instruments and of tables.

I suppose the problems of gunnery are the ones we think of first in connection with the mathematics of warfare. Such problems are peculiarly those of canned mathematics. But in connection with any problem which may come up for solution, it is inferred that certain initial conditions are known; and before showing you through the canning establishment, I propose to say a few words about the instruments used in obtaining these necessary data.

Powder pressure inside the barrel is measured in an experimental gun, drilled with holes at regular intervals. In each hole is set a hard piston backed by a soft metal plug of known compressibility. The compression of these plugs by a given discharge can then be measured and interpreted in terms of powder pressure in pounds per square inch.

Velocities inside the bore are measured in the same perforated gun. The holes are now fitted with cutter plugs, which project into the bore and are sharpened at the other end. When the passing shell forces the plug up its hole, this sharp end cuts a wire, breaking a circuit and making a spark. The spark passes from a tiny metal point to the smoked edge of a rapidly-rotating disk, burning a hole in the sooty coating. A number of the disks are mounted on the same shaft, and the successive plugs connected up so as to mark successive disks. This does away with the confusion that might result from a lot of marks on the same disk. The average velocity of the shell in each interval of the gun is computed directly from the measured distance between the corresponding spark-marks; we have $D/R=d/r$, with everything but $r$ known.

Similar in principle is the chronoscope for measuring velocities during flight, illustrated in Fig. 1. The shell

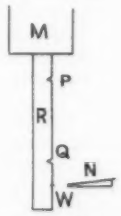



**Fig. 1**

here breaks successive circuits by passing through wire screens. In the first circuit is a magnet $M$, from which hangs a metal rod $R$; when the circuit is broken the rod falls. The breaking of the second circuit kicks a little sharp-pointed instrument $N$ forward against the falling rod, nicking it at $P$. The lag is greater in the second circuit than in the first. This is compensated by placing magnet and nicker in a single trial circuit. When this is broken the rod falls and the nicker jumps; and all measurments are made from the nick $Q$ thus obtained rather than from the projection $N$ of the nicker point upon the rod. The arithmetic of the device is, of course, the same as that of the last.

Sometimes we want information about the recoil. The very elegant apparatus for giving us this consists of a tuning fork of known period, mounted to vibrate vertically. A stiff bristle attached to this just brushes against a smoked panel fastened to the side of the gun, and of course paints there a complete picture of the recoil—velocity, acceleration, distance covered.

So much for instruments of measurement. Let us pass next to the canning factory where the relations between the velocities, angles, distances and times of flight are worked out and put up in neat packages for the gun officer to take home. We know, of course, that a projectile fired in a vacuum would trace out a parabola. But our gunners have never mastered the art of shooting in a vacuum; and there might be difficulty in getting the enemy to take up his position in a vacuum to be shot at. So we have to practice gunnery under atmospheric conditions.

This introduces a complication. In a well-ordered universe set up for the special convenience of the mathematician, atmospheric resistance to the passage of a solid body would conceivably be constant—constant with respect to the velocity of the body, with respect to size and weight, with respect to any other conditions which we might impose upon the problem. Unfortunately this is not the case; resistance varies in one way or another with velocity, with size and weight, and with other factors.

Instead of speaking of the net resistance of the air to the passage of the shell, I shall for the present defer to convention and talk about the shell's ability to make head against that resistance. The one, of course, is numerically the reciprocal of the other. This driving power, or figure of merit of the shell, is called the ballistic coefficient and designated by $C$. Obviously enough $C$ varies directly as the weight of the shell, inversely as the square of its diameter; but this is only a beginning.

There is for one thing the factor of shape. It is clear that a blunt shell will suffer more from the air's resistance than a sharper one. So we have to strike upon a standard shape, assume that $\kappa$, the factor of shape, is unity for that shape, and determine its value for other shapes. The standard shell is taken as one with an ogival head struck on a radius of two diameters. Convention demands that we write $\kappa$ in the denominator of $C$, so for better shapes it will be less. Thus for an ogival head on a radius of four diameters—a four-caliber head, as it is called—$\kappa$ is .72; for an eight-caliber head it is 0.5. For an absolutely flat head upon a cylindrical shell $\kappa$, on the other hand, would be 2.7, while for a similar head, with rounded shoulders, it would be about 2.

Then there is the factor of steadiness, $\sigma$, which likewise goes in the denominator of $C$. A shell that wabbles badly will present periodically a greater resisting surface to the air than one that travels with normal steadiness. Modern gun construction is so well worked out that for all guns and all shells at direct fire $\sigma$ is practically unity. But any shell wabbles more at high angle fire than we should like to have it, so $\sigma$ varies with the initial angle. Thus at angles of 45 degrees or more the trajectory has a very sharp vertex. The shell cannot negotiate this turn with complete success, so for the first part of the descent it sets at an angle of some 20 degrees with its own path, gradually settling down into the correct position, one of appproximate tangency to the path. Then, too, we read that the Germans have recently found it necessary to put in temporary use guns with badly worn rifling. Under such firing conditions the shell loses part or even all of its spin, so that it is possible for it to fall blunt end down, or actually to capsize and fall sideways, enormously increasing the value of $\sigma$. For the low velocity mortars and howitzers ordinarily employed at high-angle fire a fair value of $\sigma$ for angles exceeding 30° is 1.2.

The proper value of $\kappa$ is known and constant for a given gun. In determinining $\sigma$ a good deal depends upon local and temporary conditions. The factor of tenuity, $\tau$, which must next be fixed, depends entirely upon such conditions. It is established experimentally that the resistance of the air varies directly as its density. So the ballistic coëfficient varies inversely as that density. Moreover, it is found that excellent results are got by assuming the air's density throughout the flight to be equal to its density at the average height of flight. Because of the lower velocity near the vertex, the average height in a parabolic path would be two-thirds that of the vertex; and this assumption of a parabolic path, it turns out, leads to no appreciable error in this connection.

Now under standard conditions—barometer 30 inches, temperature 60° F., humidity 67 per cent—air weighs 534.22 grains per cubic foot. Tables are furnished giving weight of air for certain combinations of barometer and thermometer readings. The gun officer has to look at these instruments, read from his table, usually by interpolation, the weight of air for the observed conditions at the level of the ground, correct the result for the observed humidity, and divide by 534.22. Then he has to get the tenuity at the mean elevation $h$ of his projectile by means of the formula $\tau_h=\tau_{0'}\ (1.00003h)$, or from tables compiled from that formula. The result of all this calculation is $\tau$, and since it is smaller than unity when the air is rarer than the standard, it, too, goes in the denominator of $C$.

It would seem that we have accounted for everything in the world now, and that there is nothing else to think of. This is not quite the case. Some of the formulae which we are presently to use involve errors with initial angles greater than 10 degrees. An Italian artillerist has worked out a factor of correction for these errors which is a function of the initial angle. This is called, after its originator, Siacci's Beta-function. For angle of fire 11 degrees it is 1.01, and it increases until for 45 degrees it attains the very considerable value 1.26.

We have now $C=\frac{w}{d^2\kappa\sigma\tau b}$; and if $R$ is the total resistance which the air offers to the passage of any shell, and $p$ the resistance to a shell of unit weight and diameter, considered as a function of the velocity alone, we have $R=\frac{p}{c}$. It is then most natural to ask for an analytic representation of $p$ in terms of $v$. But, as the old farmer at his first circus said upon beholding the incredible spectacle of the giraffe, "Shucks! They ain't no such animal." All other factors fixed, resistance is indeed a function of velocity, but one that defies all simple analytic representation, one concerning which we can hardly make any definite statement other than that it always increases with $v$. Its graph (Fig. 2) bears a




**Fig. 2—Curve showing resistance of the air to a projectile 1 inch in diameter**

strong resemblance to the snakes which we have learned from bitter experience to expect from the weaker students in analytic geometry. Among other eccentricities, it has a tremendous kink in the general neighborhood of the velocity of sound, and another at about 2,413 feet per second—the speed at which air rushes to fill a vacuum. There must be something in this double coïncidence, but what or why no man knows. Incidentally, this is as good a place as any for me to point out that if a shell exceeds this velocity of 2,413 feet per second, it outstrips the efforts of the air to close in behind it, and thus leaves a vacuum in its wake.

Euler, among others, amused himself by deducing what the path of a projectile would be if $p$ varied as the square or the cube of the velocity. Such exercises must now be put in the class of diversions, harmless and useless in equal measure. The determination of the atmospheric resistance, in pounds, to a unit projectile 1 inch

*Address to the New York Section of the Association of Teachers of Mathematics for the Middle States and Maryland, May 11, 1917.

in diameter and one pound in weight of the standard shape and under the standard conditions already defined, is wholly empirical. Under these conditions this projectile is fired again and again, and its velocity at various points in its path measured. Comparing the results with those that would obtain if atmospheric resistance were absent, it is easy to deduce the retardation and hence the resistance. In every case, of course, the angle of fire is zero, so that the effect of gravity in diminishing the velocity in the path may be ignored.

The data thus secured have been carefully averaged from countless trials. Together with the differential equations of motion in a resisting medium

$$\frac{d^2x}{dt^2} = -\frac{gp}{C}\cos.\ I; \qquad \frac{d^2y}{dt^2} = -\frac{gp}{C}\sin.\ I - g$$

they constitute the raw material from which are constructed the standard ballistic tables that form the chief output of the cannery of war-time mathematics.

These tables are of two sorts—the ballistic tables proper, and the range tables. The former are compiled upon the assumption that we are dealing with direct fire—defined as fire at lower initial angles than 10 degrees. Under these conditions the effect of gravity can be ignored, and the tables constructed almost without reference to the calculus at all.

The first two columns merely set forth the values of $p$ for values of $v$ at intervals of 10 feet per second, as shown upon the graph. Column III gives $\Delta T$, the time necessary for the projectile to fall from the given velocity to the next one. Since mass × acceleration = force × time, we have, of course, $\Delta T = \Delta v/gp$, where $\Delta v$ is 10 and $p$ is taken as the mean between the two values concerned. Then Column IV is merely a summation of the $\Delta T$'s to get $T$, and it works like a definite integral; we find the time it takes the velocity to fall from $v_1$ to $v_2$ by subtracting one entry from the other. In working tables for field use the $\Delta T$ column is usually omitted, since it consists really of nothing but working figures.

Column V exhibits $\Delta S = v\Delta T$, the distance traveled while the velocity is dropping $\Delta v$ feet in $\Delta T$ seconds. And of course in column VI we have $S$, the summation of the $\Delta S$'s: again we subtract the two entries to find the distance traveled in falling from $v_1$ to $v_2$, and again we often discard the $\Delta S$ column from our finished tables.

The next item involves the effect of $g$, the gravitational acceleration, in turning the projectile from its initial course. We still work upon the assumption that the initial angle approximates zero; so replacing the cosine by unity and the sine by the angle itself, and making certain other modifications in the differential equations, we get values of $\Delta D$ and $D$, the angle which the axis of the projectile makes with the horizontal plane. This of course is the angle $I$ of the differential equations, only here it is measured in degrees, there in radians. As in the previous case we read $D$ by subtraction and discard the $\Delta D$ column; and while our results are avowedly derived for low angle fire only, Siacci's Beta-function makes them applicable to all angles.

To complete the ballistic table by the addition of a column showing the height of the projectile above the ground at any point of the trajectory, and to compile range tables which shall exhibit the range for various initial angles and initial velocities, we must fall back upon the differential equations. And here we run into deep water; for in every case we have to deal with an integrand involving $p$. Now $p$ is a variable, and before integration can be undertaken it must be replaced by its functional value in terms of $v$. But, as we have seen, this is impossible; so we are at an impasse, and assumptions are in order.

The particular assumptions with which the Gordian knot is cut are rather ingenious. The trajectory is thought of as divided into several partial arcs; and certain of the variables in the intractable integrands are replaced by their mean values over successive arcs. In this way it is possible to plot the trajectory arc by arc, and to control the error by means of Siacci's Beta-function.

The range tables constructed from the results of such computations consist of double entry rows and columns setting forth the range as a function of initial angle and initial velocity. From the ballistic tables and the general range tables it is customary to compile special tables for use with a particular gun of known muzzle velocity. These exhibit, for angles of elevation no more than five minutes apart, not merely range, but velocity and angle of impact, time of flight, penetration into wrought iron, and various other items of less consequence. Even in the absence of such a table, however, it is possible, the range known from the general range table, to refer back to the ballistic tables and pick out the remaining velocity of the projectile at the end of its flight, the time of flight and the angle of fall. All general tables, of course, are for unit shell at standard conditions. Since the constant $C$ enters linearly in the differential equations it enters linearly in all results, and has to be used as a modifying factor. The presence of the Beta-function in this constant adjusts what would otherwise be serious error. With the special table giving all data for a particular gun, of course, the factor of correction consists only of $r$. All the other factors of $C$ are constant or at worst functions of the initial angle which forms the argument of the table itself; and accordingly these can be considered in compiling the table.

With these tables in his hands the worst thing that can come into the life of the gunner is that he be compelled to select the right table and follow a few cross references through its columns, compute the value of $C$ and multiply. Thus if he is shooting at a moving mark, he must know the time of flight in order to allow the enemy the proper time to catch up with the shell fired in front of him. If, as is universally the case with all heavy artillery in the present war, he is using a time shell instead of a contact one, he must again know time of flight, this time to regulate the length of the fuse. If the enemy is using, at known range, a gun of known ballistic properties, his engineers will want to know its remaining velocity and angle of fall so as to estimate its effect upon our works, and our engineers will want to know the same things so as to construct those works at the most advantageous angle to secure deflection, and of a thickness to withstand penetration, if this be possible. If the enemy has been located at $B$ (Fig. 3) on the far side of a hill, and we must know, without making the trial shot that might reveal our position $A$, whether a shot ranged at angle $\theta$ to hit him will clear the hill, or whether we must fall back to $A^1$ and fire at a higher angle $\theta^1$, we must ascertain the height of our trajectory at the distance of that

Fig. 3

hill. A wide variety of such problems the gunner, of course, will solve by means of his tables. But in the daily routine of so pointing his gun that it will hit an enemy in a given position, we can, through the agency of range finder and sight, do even better by him.

A range finder is a machine for automatically solving triangles. We set it according to the known parts, and read off on a scale the unknown part in which we are interested—the distance of the object being ranged. While manufactured in a wide variety of models, mathematically range finders fall into just two classes—the horizontal and the vertical types. (Fig. 4).

The latter is for use in naval work, either in ranging ships from an elevated point on shore, or for use in the crow's nest. Obviously in training a telescope upon a ship from either of these points, a certain angular depression will be necessary. The telescope, attached to a circular scale, registers this depression automatically; and since the height of the instrument above sea level

Fig. 4

is known, the triangle is then determined. It is usual to mark the scale with values of tan. $\theta$, or if designed for use at a fixed and known height, $a$, with $a$ tan. $\theta = b$, so that the range can be read directly from the scale.

The horizontal range finder is for more general use. It applies the principle of binocular vision to determine the distance. Our two lines of vision to an object are not parallel; we must look at it cross-eyed; and knowing the distance between our eyes, the angle of ocular adjustment would measure the range.

A layman might object that the contemplated base-line is too small in proportion to the range to give a reliable reading, even with mechanical aid. A mathematician might retort that the astronomer measures star distances of ten light years and more from a base line about seventeen light minutes in length, and that seventeen minutes to ten years is a far smaller ratio than two and one-half inches to ten miles. In such an argument the layman, for once, would be right; the ranger has to attain so much greater accuracy than the astronomer that the distance between his eyes is in fact an insufficient base-line for him.

So we have to expand this distance; and the horizontal range finder is the result. (Fig. 5.) Two telescopes, $A$ and $A^1$ are mounted end to end in a carrying tube, with their objectives $K^1$ and $K$ in opposite directions. At the eye end $L$ and $L^1$ of each is a prism $P$ and $P^1$ which deflects the light passing through both into a common eye-piece $B$, set in the side of the larger tube. On the opposite side of this tube, at either end, are other prisms $Q$ and $Q^1$ to deflect into the telescope light falling laterally upon the

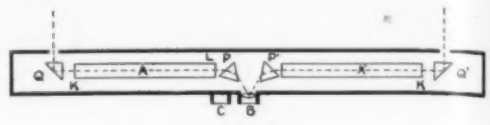



Fig. 5

tube. This light then follows the course of the dotted lines. The observer places his right eye at the common eye-piece of the two telescopes, and of course sees two images of the object being ranged. By means of a thumb screw he turns the prisms through equal angles until these images coincide exactly. In the meantime his left eye is at another eye-piece $C$, in which is visible a scale and pointer; and this registers the amount of rotation that was necessary to bring the axes of the prisms out of their original parallel position into intersection in the object being ranged. This scale, of course, is not marked in angles, but is calibrated according to the distance between the two apertures so that the operator reads off from it, not angles which have then to be converted into ranges, but ranges themselves. In other words, the range finder, in either of its forms, represents twice-canned trigonometry; the results of triangle solution are canned in the ordinary trigonometric tables, and extracts from these tables, by means of which triangles of a given base, $a$ or $QQ^1$, may be solved, are canned again on the scale of the range finder. The instrument is then fool-proof; anybody with enough eyesight and intelligence to know when he is seeing double, should be able to operate it after once being shown how. In some models, it should be remarked, the prisms are replaced by mirrors; but mathematically this does not alter the instrument.

The range known, the artillerist turns at once to his sights. At one time it was actually the practice to look in a book to see what angle of fire to use, and then to set the gun at that angle by means of a protractor. Nowadays we take advantage of the fact that a given gun always shoots the same shell with the same charge, and that initial velocity is therefore a function of the gun, and will not change until we change the gun. We simply attach a vertical sight to the gun, and on it we can the portion of the range tables relating to the initial velocity of that particular gun, entering, of course, on each mark, not the angle, but the corresponding range. When we are given the range as 1,760 yards, it is then only necessary to adjust the hind-sight $H$ (Fig. 6) so that the 1,760

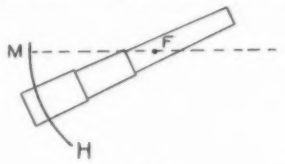



Fig. 6

mark $M$ on it is in horizontal alignment with the fore-sight $F$. In short guns the fore-sight will be at the muzzle; in long bores this would require too long a hind-sight and too tall a gunner, so the fore-sight must be mounted somewhere along the bore, and the hind-sight, which may be straight or curved, graduated accordingly. But these are details. The really significant feature of the elevation sight is that when an enemy is visible, rifle or gun is trained upon him by alining the two sights upon him, just as in short range direct fire—and this of course is equally valid when he is above or below the level of the gun with which we are going to blow him off the map. Then when he is invisible we follow the same procedure, using a spirit level to strike a true horizontal line between $M$ and $F$. So the journeyman gunner doesn't have to learn a new procedure for high angle fire at all. The canned mathematics of the range table is canned a second time for his special benefit upon his sight. It must be correctly canned, however; for if the range be wrong, or the sight be wrong, the sighting may be ever so correct and the shell can only plough up the field a few hundred yards in front of the enemy or sail harmlessly over his head.

When the gun has been properly sighted for range it is still necessary to sight it for direction. Usually the two sights are separate, so that they can be adjusted simultaneously by different men. There can hardly be anything new to the reader in the principle of directing a gun by means of the direction sight; but in its application there enters the interesting factor of drift.

All modern ordnance is rifled. That is to say, the inside of the bore is cut with spiral grooves from end to end, between which project sharp spiral ribs. The body of the shell is of such claibre that it just rests lightly upon these ribs; but the copper rim at the rear has the extreme calibre of the bore, from the bottom of the grooves. As the shell passes up the bore, the sharp, hardened ribs of the rifling cut into this soft copper rim, making grooves in it that have to follow the ribs in their

spiral course round and round the inside of the gun. The whole shell consequently acquires an axial rotation as it traverses the bore, and leaves the muzzle with a pronounced spin, which it maintains until it strikes. (Figs. 7 and 8).

This spin adds to the range and makes the flight sufficiently steady to be subject to mathematical laws; it alone renders it possible for the long, thin projectile to remain head on throughout its flight. This it is that makes essential the use of copper for shell rims, a necessity so embarassing to Germany at the present time. But the spin produced by the rifling also causes the shell to drift to one side, off its course. One is tempted to describe this offhand as analogous to the curve of a pitched ball, or the spin of a sliced golf ball. In reality, it is a different phenomenon, and one not at all well understood. The baseball or golf ball rotates in a

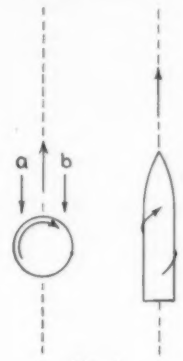



Fig. 7

horizontal plane containing the line of flight, while the shell rotates in a vertical plane perpendicular to the line of flight. The slice and the curve ball are explained on the ground of greater pressure on the one side of the advancing face of the ball, due to the slipping off of the air in the direction of rotation. In the case of the shell, rotation is not across the advancing face at all, but around it; so another explanation must be sought.

About a year ago the German technical papers were devoting a good deal of space to this phenomenon, and the following suggestion was brought forth: The ogival head, in following around after the tangent to the path, as it is forced to do by the inertia of the spin, causes a compression of the air beneath the nose in excess of

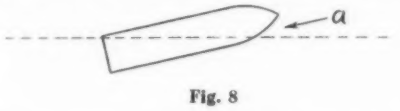



Fig. 8

that existing above. The shell always rides at a slight angle to its own path, and there is a sort of denser air cushion under the advancing head; by virtue of its spin, the shell rolls laterally on this cushion. About that time the German mails ceased to be intermittent and became non-existant, and I have not seen a current German journal in over eight months. Consequently I can not say how the discussion terminated; but this explanation impressed me as a plausible one. At any rate, the bald fact is that the shell drifts to one side—to the right when shot from a gun with right-handed rifling—and that this deflection increases with the range. Of course, then, after sighting for direction, an arbitrary adjustment of several degrees to the left is necessary.

The possibilities which lie in this complete mathematical control of gun fire reach their climax in the barage fire so extensively employed by our allies. Not many years ago this would have been out of the question; the only way to attempt the barage effect would have been to form a single line of identical guns, shooting at the same angle; and it would have been physically out of the question to place them sufficiently close to give an effective barage, to say nothing of the problems of supply, concealment and defense. But today we can distribute guns of all types over an area five or ten miles deep, give each crew the precise range and direction, and go to bed with the secure knowledge that along a given line between us and the enemy, or behind his first defences, there is an impenetrable screen of high explosive shells descending at all angles and all velocities.

It is such artillery coöperation raised to the *n*th power that has made possible the carefully organized operations of our allies in France this spring. An attack is planned several days ahead, and a schedule laid out which must be followed to the instant by all concerned. For perhaps two days beforehand the objective point in the enemy line is isolated from all supply and all relief by a violent barage descending behind it, and at the same time cut to pieces by intense fire directed at it. When the appointed moment comes, the direct fire ceases, and the barage is shifted to a point between the hostile first lines.

Under cover of this curtain the attackers climb leisurely out of their trenches, form in line, and proceed at a walk across No Man's Land. At scheduled time the barage advances; when necessary the advancing line comes to a halt to wait for the barage to move. The whole journey across No Man's Land is thus screened, save for the last dash of from thirty to fifty yards, after the barage has finally been shifted to a point behind the hostile trenches.

Of course the barage does not afford complete protection. In any event losses are severe in the final rush. But it is plain that this scheme of attack, carefully carried out, makes possible sustained offensive without the excessive losses which characterized the similar operations of the previous years of the war. And this scheme rests wholly upon two factors; the absolute mathematical control of the artillery fire, and the absolute mathematical accuracy with which the women munitions workers of England and France make up the shrapnel shells. If the charging infantrymen could not approach to within a few yards of the descending curtain, with confidence that no undercharged shell is going to fall among them and work havoc, these tactics would be out of the question.

I have almost used up my time, and I have spoken of nothing but gunnery. This is really appropriate, because the problems of observation, which formerly shared with those of gunnery the domain of war-time mathematics, have within the past three years been granted a divorce. Observation is no longer a matter of trigonometry; it has become a matter merely of aviation and photography. The whole region behind the enemy's first line is photographed every day and many times a day. These photographs, taken from a known height and with a known lens, are scaled and charted by geometry too elementary to require description. Nothing can take place that is not at once observed by the aviator, reported, and referred to the proper spot on these maps. Then, if it is some activity that should be broken up, a few words by telephone to a gun station, giving merely the indexed location on the map, is sufficient to start the breaking-up process.

The aviator, it is true, has a number of ingenious pieces of apparatus to enable him to determine his altitude, the true vertical direction, the amount of sideways drift, etc.; but I pass over these as being hardly within the field of mathematics. Similarly, I refrain from mentioning the mathematics of war-time engineering, since it is in no essential different from the corresponding technique of peace. I believe I have covered the field of distinctively war-time mathematics sufficiently to give a fair idea of what lies therein, so I will go no further.

## Platinum in the Ural Region

THE following points concerning platinum have been furnished by Prof. Louis Duparc of the Geneva University, who is an eminent specialist in all researches about this metal, having spent a long period in the Ural region in connection with geological explorations as well as extraction of the metal. He commenced this work in 1900, starting with the Koswinski-Kamen platinum field, and after a considerable time he came to the conclusion that this metal occurred only in a basic rock known as dunite. He then made explorations over the vast regions of the North Ural, and studied all the known deposits in the region, after which he modified his first opinion, for he found that platinum also occurs in another rock, pyroxenite; but with dunite, these appear to be the only rocks containing platinum. This metal is also found in streams and in alluvial soil. The dunite rock may be said to invariably contain platinum wherever it is found, but the pyroxenites only contain it under certain conditions.

Very few persons have ever seen platinum in the native state imbedded in the rock, and specimens of this kind are extremely rare. In the case of dunite, platinum is seen in two general forms, first, crystallized directly in the rock along with the rock material, or second, crystallized with chromite and consequently localized in the regions where this mineral occurs in the rock. This second case is the most frequent, no doubt. In dunite, platinum is found either in small isolated crystals or in masses of a certain size which in certain cases are set free from the rock and roll in the water courses in the shape of small nuggets. In chromite (one of the constituents of dunite rock) the platinum crystals are found either disseminated irregularly in the masses of chrome iron or else the platinum forms an intermeshed structure with this mineral, in which the chromite parts are held together by the platinum which acts as cement and follows the contours of the mineral parts. In this way the platinum makes up a veritable sponge, with the mineral lodged in the cavities, as can be seen by making a section of the rock, and the role played by the platinum in uniting the chromite crystals is very clearly observed.

The disposition of the metal in the pyroxenite rocks is quite analogous to the preceding, and two general forms are also noted; first, the platinum is crystallized directly with the pyroxene, and second, it is associated with the magnetite which forms aggregations in the rock. It is more difficult to find platinum in this rock than in dunite. But, in the Gussewa region, there are often found nuggets in which the metal is seen associated with the rock, and this allows of making good observations. The platinum is seen molded around the large pyroxene crystals after the manner of a cement, and when the crystals disappear, because of an alteration produced in the alluvion, their imprints can be clearly seen in relief in the platinum; and this is the cause of the irregular and hollow shapes of certain nuggets of pyroxene origin. Because the platinum appears as a more recent or consolidating element, holding the crystal parts of the rock together, it should have a lower melting point than these rocks. However, chromite melts at 1,840 degrees C. and the other minerals still lower. But the melting point of platinum is usually given as about 2,000 degrees. This apparent contradiction may be explained by the fact that (as the author demonstrates) native platinum is not a pure element, but a complex alloy, and it is well known that alloys melt at a lower point than their component metals.

The principal natural alloys of platinum contain the following metals, but these are in very variable proportions. Osmo-iridium is the first of the series, and this term includes definite compounds of osmium, iridium and always a certain amount of ruthenium. But it is to be noticed that the osmo-iridium is not in reality alloyed with the platinum, but its masses are surrounded by the latter metal, so that the former appears as if imbedded in it. Here the osmo-iridium forms flat hexagonal crystals. Iridium is found alloyed with platinum in variable proportions which sometimes reach five or six per cent. Rhodium, which is closely related to iridium, is nearly always seen in the various native alloys, but always in a low degree, not over 0.3 to 1.0 per cent. Palladium is a constituent of all the natural alloys of platinum, but it rarely exceeds 0.5 per cent. While it is true that gold is often found in native platinum, it is often claimed that it comes from a foreign source and has nothing in common with a natural alloy. In fact in the Ural regions it is rare to find gold, and the proportion is very small as seen in platinum grains separated under the hand glass. But in British Columbia there are found platinum nuggets shot with native gold, and this is a proof that gold may exist in the form of an alloy. Copper is constantly found in the native alloys in proportions varying from 0.1 to 5.0 per cent, and nickel is of very frequent occurrence, but only in small quantities, and never over one per cent. After platinum itself, iron is the metal which occupies the most important place. The amount is quite variable and this lies between three and twenty per cent. Because of the iron, such alloys are more or less magnetic, and two kinds can be distinguished; the ferro-platinum, which is usually attracted by the magnet, and the polyxene, which is not so attracted, so that the native platinum can be run under the magnet and separated into two parts, variable of course. For instance at Taguil nearly all the metal is attracted, while at Kitlim only a small part can be attracted by the magnet. Native platinum grains or nuggets are treated by aqua regia, which dissolves all the metals except the osmo-iridium which is left as a crystalline powder. When the osmo-iridium is very abundant, for instance in the nuggets, the platinum can be dissolved away so as to leave a veritable sponge formed of osmo-iridium in flat crystals. Simply as an example—for the figures vary widely—we note a percentage analysis of native platinum. Osmo-iridium 1.50 platinum 77.16; iridium 2.68; rhodium 0.54; palladium 0.27; gold 0; copper 3.39; nickel (traces); iron 14.72 per cent. This specimen is selected as showing the entire number of metals in its makeup, except gold, which occurs in some other specimens. In another case there were only four metals present, which appears to be the minimum for the various analyses given by the author.

## Industrial Schools in Ceylon

TECHNICAL and industrial schools in Ceylon give instruction in plumbing, sanitary engineering, railroad shop work, telephone and telegraph inspection, shorthand, typewriting, pharmacy, medicine, chemistry, and physics. Thirty-nine schools give instruction in carpentry, printing, bookbinding, shoemaking, tailoring, blacksmithing, lace making, dressmaking, embroidery, cooking and gardening. Nearly all of these schools teach lace making, but cooking is taught in only two, masonry in one, gardening in one, blacksmithing in one and shoemaking in two.—*The Philippine Craftsman.*

## NEW BOOKS, ETC.

THE NEW YORK CHARITIES DIRECTORY. By Linn D. Miller .New York: Charity Organization Society, 1917. 8vo.; 500 pp.

The Charities Directory has long outgrown its title and now covers every phase of social betterment work. Nearly all responsible agencies for any social, civic, religious or educational work connected with New York City are listed in alphabetical order, with their aims and activities and their officers. A topical index makes it possible to find any agency from the nature of its work, when the name of the agency is unknown; a list of churches is given, arranged by denominations and boroughs. Persons prominent in social service may be located in the name index and their connections readily ascertained. The information given has been compiled with the coöperation of the various institutions, and much time and care have been expended in an effort to make the Directory inclusive and authoritative. The present edition discloses improvements both in general contents and typography.

THE PRINCIPLES OF ELECTRIC WAVE TELEGRAPHY AND TELEPHONY. By J. A. Fleming, M.A., V.Sc., F. R. S. New York: Longmans, Green, & Co., 1916. 8vo.; 928 pp.; illustrated. Price, $10.

The progress made in the art of radio communication during the six years that have elapsed since the second edition of this substantial work has not been ignored in the new edition. The subjects are thoroughly treated under the heads of electric oscillations, electric waves, radiotelegraphy and radiotelephony. The first head includes high-frequency currents and electrical measurements, and damping and resonance; the second, stationary waves on wires, radiation, and the detection and measurement of waves; the third, the apparatus of wireless, the stations, radiotelegraphic transmission, and radiotelephony. The selection of material has been so carefully made as to give the reader the essential and comprehensive facts in the progress and present standing of the art; among improvements noted in the new edition are the omission of antiquated history and apparatus and the addition of a chapter on the transmission of radiotelegraphic waves over the earth. Numerous plates, cuts and diagrams add much to the clarity and value of the work.

THE ORIGIN OF FINGER-PRINTING. By Sir William J. Herschel, Bart. New York: Humphrey Milford, 1916. 8vo.; 41 pp.; illustrated. Price, 50 cents.

After careful study of the claims of China and other countries as the birthplace of our present most efficient finger-print system, Sir William Herschel comes to the conclusion that he himself was the first to use such impressions for comparisons by which identity might be established. It is a very interesting story he tells of how, in the pursuance of his duties under the old East India Company in Bengal, he came to hit upon the finger-print idea; and how, after years of the collection and study of such signatures, he became convinced of the remarkable persistency of the designs and their unfailing success in identification. His efforts to establish the system in the Indian courts did not succeed, but he has had the satisfaction of having the truth of his early claims admitted by the men then in office. His pamphlet contains finger-print reproductions of many well-know persons; in two instances we have the prints of the same individual as child and man, and always the identity is unmistakable, the persistency of the markings firmly established.

TIDAL SOUNDINGS AND DIAGRAMS. By W. V. Merrifield, B.A., F.R.A.S., Headmaster Liverpool Nautical College. New York: Longmans, Green, & Co., 1916. 8vo.; 31 pp.; with diagrams. Price, 50 cents net.

This pamphlet gives useful instruction in three brief chapters. The first shows how to find from the Tide Tables of 1916 the times of high water ;the second explains the reading of charts and the reduction of soundings, with exercises to be worked out and answers against which results may be checked; the third treats of charts and chart problems, the determination of position, the three-point problem, the counteraction of currents, etc.

THE ORGANISM AS A WHOLE. From a Physicochemical Viewpoint. By Jacques Loeb, M.D., Ph.D., Sc.D. New York: G. P. Putnam's Sons, 1916. 8vo.; 389 pp.; 51 illustrations. Price, $2.50 net.

Some extremely difficult problems confront us in any study of the organism as a whole, perhaps chief of which is the question as to how a conglomerate of independent characters, such as Mendelian heredity gives the individual organism, can be shaped into a harmonious entity. The author's theses are well presented, and his arguments are closely wrought out to a mechanistic conclusion; in the course of the work we are called upon to consider, as necessary steps toward the attainment of our physicochemical goal, such attractive subjects as the specific difference between dead and living matter; regeneration; the determination of sex; animal instincts and tropisms; the influence of, and adaptation to, environment; evolution; and death and the dissolution of the organism. The trend of these investigations is toward the conclusion that the organism owes its unity to the fact that the cytoplasm of the egg is the future embryo upon which the Mendelian factors in the chromosomes can impress only individual characteristics, by giving rise to special hormones and enzymes; this conception would have a distinct bearing upon evolution, suggesting that genus—and species—heredity are determined by the cytoplasm of the egg, while the Mendelian characters may contribute nothing, or at best very little, to the formation of new species.

THE MENACE OF JAPAN. By Frederick McCormick. Boston: Little, Brown & Co., 1917. 8vo.; 380 pp.; with map. Price, $2 net.

The extreme complexity attending the United States' participation in Chinese affairs and her efforts to keep open the Open Door has prevented even more intelligent readers from recognizing the exact situation; their understanding of our offense against Japan in this matter is still more vague. The author, who is a journalist with extensive knowledge of the eastern situation, gives us what purports to be the secret history of the unsuccessful diplomatic struggle that ended in the loss of our prestige in the Pacific. Japan's attitude toward us is interpreted in the light of her actions and alliances, and the author's conclusion is well expressed in the title of his comprehensive volume.

DISCOVERY, or The Spirit and Service of Science. By R. A. Gregory. New York: The Macmillan Company, 1916. 8vo.; 348 pp.; illustrated. Price, $1.75 net.

The object of this work is to promote a more sympathetic attitude toward scientists and to remove widespread misconceptions as to the meaning and influence of science. It is no doubt true that until scientific investigation crystallizes into some practical device the public know little and care less about the men who are giving their lives unselfishly toward the advancement of knowledge. The author brings out the high value of a direct contact with nature and an unmercenary investigation of her laws; by means of interesting quotations and anecdotes he succeeds in making our great men of science very real and human to the reader, and the narration can hardly fail to evoke the spirit of emulation in many who have hitherto been lukewarm. It discusses such relationships as belief and evidence, inquiry and interpretation, and law and principle, devotes chapters to the conquest of disease, scientific motive, and practical purpose, points out to us the shadows of things "across the border" of the known, and leaves us with a wider horizon and a larger appreciation of those whose amazing labors have given us our heritage of modern civilization.

RICHARDSON BUSINESS MEN'S SLIDE RULE. With directions for its use by J. J. Clark, M. E. $5. 4212 24th Pl., Chicago: Geo. W. Richardson.

The mechanical and electrical engineer has long held the slide rule to be practically indispensable; here we have a similar device especially adapted to the needs of the business man, and offering him prompt answers to his daily problems in multiplication and division. Percentage, interest and discounts are readily found; part time wages are conveniently computed; stock transactions, profit and loss, taxes and chain discounts provide other instances where the rule may be used to advantage; its use does not, however, extend to addition and subtraction. An illustrated book of instructions accompanies the device, enabling anyone to grasp with little trouble the principles upon which it works. The rule has really but two essential parts, the body of the rule and the slide, although a transparent runner carrying a hair line is included, to facilitate close readings. The construction is of metal, and all precautions have been taken against rusting, warping and binding. It would seem that the progressive business man should find daily use for this attractive and time-saving device.

RECREATIONS IN MATHEMATICS. By H. E. Licks. New York: D. Van Nostrand Company, 1917. 8vo.; 160 pp.; 60 illustrations. Price, $1.25 net.

The author has brought together from many sources a great variety of mathematical problems ranging from the logical and useful to the frivolous and absurd. Students will recognize among them many old friends beside others that will doubtless present a new face to them. The discussions are grouped under the various branches of mathematics, and they comprise what the author likens to a "curio collection" that will profitably while away an idle hour, or provide amusement for a gathering of friends. It is rather to be regretted that in most cases no answers to the problems are given.

PRELIMINARY MATHEMATICS. By Prof. F. E. Austin, B.S., E.E. Published by the author from Hanover, N. H., 1917. 12mo.; 173 pp. Price, $1.20.

Among the more definite aims of this text-book, which has been remodeled for the use of eighth grade, junior high school and high school students, is that of making easy the transition from arithmetic to algebra; its main object is to fit the pupil to solve problems, and to this end it explains many points omitted from the ordinary text-book with which it is intended to be used as an auxiliary. It is also valuable as a reference book; this mode of use is furthered by the inclusion of various tables and the insertion of a comprehensive index.

PHYSICAL LABORATORY EXPERIMENTS FOR ENGINEERING STUDENTS. By Samuel Sheldon, Ph.D., D.Sc. and Erich Hausmann, E.E., Sc.D. New York: D. Van Nostrand Company, 1917. 8vo.; 140 pp.; 40 illustrations. Price, $1.25 net.

The thirty self-contained experiments here offered were originally prepared for sophomores of the Polytechnic Institute of Brooklyn; they are peculiarly adapted to the needs of candidates for engineering degrees Each exercise occupies about three hours' time, and the course would therefore extend over two semesters. Frequently the result experimentally obtained may be checked with the theoretical result calculated from the constants of the apparatus, and this feature tends to impart to the student a confidence that leads to efficient work based upon intelligent understanding.

X-RAYS. By G. W. C. Kaye, M.A., D.Sc. Capt. R. E. (T.) New York: Longmans, Green & Co., 1917. 8vo.; 299 pp.; illustrated. Price, $3 net.

Addressed to the student of physics and the scientific laity, "X-Rays" describes apparatus and methods, critically examines valuable and novel features of its subjects, and sketches the developemnt of theory and experiment. It furnishes the medical profession with a work that collects the scattered information of the journals of the day, and which is "neither recondite nor mathematical." This second edition shows thorough revision and includes original work published up to August of 1916. Five appendices deal with the production of high vacua and electrical insulators, give useful tables and data, present brief recommendations for the protection of operators, and quote an interesting interview with Prof. Röntgen.

HIGH FREQUENCY APPARATUS. Its Construction and Practical Application. By Thomas Stanley Curtis, Editor of *Everyday Mechanics*. New York: Everyday Mechanics Co., Inc., 1916. 8vo.; 196 pp.; illustrated. Price, $2.

Dispensing with the merely theoretical, the handbook speaks directly to the non-technical reader and furnishes him with designs that are the results of actual experiment and construction. There is a concise explanation of the high frequency current, its production, and its uses; the principles of the transformer, condenser, spark gap and oscillation transformer are described in detail; a third section covers the construction of small high frequency outfits adapted to the class room and the home laboratory; further sections adequately deal with electro-therapeutic and X-ray apparatus, and with apparatus designed for plant cultivation; and the final section proceeds to the consideration of outfits large enough for spectacular stage productions The work embraces so much of modern practice and the later developments of science that the serious experimenter will find it excellently adapted to his needs.

AN OFFICER'S NOTES. By Captain R. M. Parker, U. S. Cavalry. Compiled by Lieut. C. C. Griffith, C. A. C. New York: George U. Harvey, 1917. 16mo.; 211 pp.; illustrated. Price, $2.

The two officers to whom we are indebeted for this summary of information have performed a distinct service to our military organization. They have given the young officer a brief, simple digest of required knowledge in army regulations, military laws, small-arms firing, field service regulations, military topography, drill regulations of infantry and cavalry, and hippology. The notes are compiled directly from official publications, and lay stress upon the more important points. Capt. Parker's long practical experience enables him to add most useful suggestions, and the essential teachings of half a dozen separate service manuals are placed at the candidate's disposal in one small volume that readily fits the pocket.

PRACTICAL DRAWING. By Harry William Temple. New York: D. C. Heath & Co., 1917. 4to.; 141 pp.; illustrated. Price, $1.50 net.

"Practical Drawing" is a really artistic work by a capable teacher, containing material for a course in practical working drawing to begin in the eighth grade, with shop problems. It is equally adaptable as a combination course in drawing and shop in the junior high school or as a text in cabinet making, wood turning, first year pattern making, concrete work, and stenciling. All these subjects are briefly but adequately set forth, and throughout the instructions the fact is impressed upon the pupil that drawing is a universal language—"the language in which art records the discoveries of science." Its value as an educational agency is emphasized, and the accompanying projects and illustrations are designed to inculcate good taste as well as to develop facility in handling drawing instruments and tools.

BIOLOGY. General and Medical. By Joseph McFarland, M.D., Sc.D. Philadelphia: W. B. Saunders Company, 1916. 8vo.; 475 pp.; 160 illustrations. Price, $1.75 net.

This well-known text, in its third edition and greatly improved form, particularly takes into account the needs of the scientific course. Living substance, with its unique nature and its interesting reactions, is traced from its problematical source through its innumerable differentiations to its most complex forms. In view of the present controversial stage of biological science, the author has avoided the formulation of laws based upon incomplete or uncertain information, preferring to content himself with a clear statement of the trend of investigation The problems of blood-relationship, infection, immunity, parasitism, inheritance, mutilation, regeneration, grafting, and senescence have been given a lengthier consideration than is usually met with in texts of this nature, and the general treatment is such as to make the work extremely valuable not only to the reader but slightly acquainted biological science, but also to the more advanced student.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